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Photo by Leif Bjorseth, Seattle Water Department.

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Watershed Management on Wild Lands

Richard E. McArdle

TWO TRENDS of major importance to the owners and managers of wild lands are becoming increasingly apparent throughout the United States. The first is the greatly increased demand for water supplies to meet the needs of expanding populations and to service new uses created by technological advances. Although present demand causes concern in many areas, the most recent estimates[1] predict that it will more than double by 1980. Corollary to the demand for more water is a growing demand for protection against the ravages of too much water—against the floods and sediment deposits that do greater damage each year as cities, highways, and industrial developments occupy more and more of our flood plains. The wild lands—the forests, ranges, and undeveloped areas—receive much of the precipitation and yield a large part of the runoff that creates these problems of over- and under-abundance.

The second major trend is the growing demand for use and occupancy of land for all kinds of purposes—for the growing and harvesting of timber; for range for domestic livestock and wild game animals; for recreational pursuits of all kinds, ranging from highly developed resorts to broad expanses reserved for wilderness; for storage reservoirs to meet flood control, water supply, and hydroelectric power needs; for urban development, highways, and airports. This expansion in use and occupancy is due in part to the same factors that augment the demand for water—expanding populations and improved technology. It is also due to increased leisure time, improved travel facilities, and higher standards of living which make it possible for more people to make greater use of larger areas of land.

The two major trends are combining to create a situation in which single-purpose use of land, either public or private, will become less and less common. The range that is grazed without consideration of other resource values, the timber stand that is harvested without regard to the effect of the logging on watershed conditions, the municipal supply watershed that is fenced or closed to all forms of use—these are beginning to disappear and will do so more rapidly in the future.

There is some danger that these two trends may themselves create special interest pressure: for the furnishing of food, fiber, and living space on the one hand and the production and regulation of waterflows on the other. In developing any plan or pattern of resource management it must be continually kept in mind that water and soil are inseparable resources—that the use and control of either must be compatible with the need to maintain both in useful and productive condition.

The knowledge and skills necessary to produce food and fiber from the soil are far advanced and being further improved through constant study. New developments are eagerly awaited and put into practice by progressive land managers.

General understanding that use and management of land and its plant cover influence waterflows has existed for many centuries. In spite of this general understanding, the search for basic knowledge of the interrelationships between water, soil, and plants and the development of technology that would make its practical application possible has not kept pace with that for farm crop production. This lag is probably due to several factors: (1) because water was free and plentiful, the incentive to enlarge and improve yields was less great; (2) because the principal physical and economic benefits from watershed management often do not accrue to the owner of land treated for watershed improvement; (3) because long periods of study are often necessary to reach understanding of single phases of a complex hydrologic process.

Whatever the reasons, the fact remains that knowledge of watershed behavior and the influence that soil and plant management

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[1]Select Committee on National Water Resources, U. S. Senate, 86th Cong., 1st Sess. 1959. Water resource activities in the United States. Committee Print No. 1. 1959.

and use have on waterflow characteristics is far from complete. Besides a better understanding of the relevant physical principles, the land manager also needs improved means of predicting in quantitative terms how changes in use will affect water yields and quality. With the present competitive demands for land, for resources, and for use of public and private capital, he must be able to show the expected return from prescribed restriction of use and the expenditure of given amounts of effort and money, both in terms of improved water supply and interest on dollar investment.

Lacking this additional information, we can still do much on the basis of present knowledge to increase soil productivity and make full use of land resources while maintaining an optimum supply of usable water. This will require general acceptance of four basic objectives that should govern integral use and management of our land and water resources: maintenance of an effectual plant cover, maintenance of soil stability, maintenance of maximum infiltration rates, and control of surface runoff.

Watershed Management Aspects of Land Uses

Timber management. — Timber stands are a vital part of the natural resource base of our national economy. Meeting future demands for forest products will require very substantial increases in forest yields. For example, based on projected medium levels of population in the year 2000, we will need to be growing 105.4 billion board feet of sawtimber, or more than double the amount grown in 1952.[2]

Harvesting timber unavoidably results in some disturbance of natural conditions. It has been amply demonstrated, however, that with thoughtful planning and careful, alert supervision, timber products can be harvested without serious effect on soil and water relationships, except in local situations such as certain municipal watersheds and very critical flood source areas.

Coordination of timber harvesting with protection of watershed values begins with the plans to open up new cutting areas. Location of roads, cutting area boundaries, yarding routes, and landing locations relative to watercourses may be critical and must be carefully studied. Areas of unstable soils, particularly those on very steep slopes, may need to be excluded from the cutting plan or harvested by special methods. Selection of methods of logging must give attention to probable disturbance of the soil mantle and damage to the water resource. Economic and local conditions may limit the selection, but within these limits that method causing the least watershed damage should be used.

A big job lies ahead in reforestation, stand improvement, and other cultural operations. Since these measures usually improve soil stability and the hydrologic behavior of forest lands, they will also benefit water resources. In planning and carrying on these measures, timing and methods should be considered because these factors may affect water values.

Forage production and wildlife habitat.—Production of forage for livestock and game animals along with the maintenance of suitable game habitat are major and essential uses of forest and range land. Practically all of the range lands and more than half of our forest lands are grazed by domestic livestock. Nearly all of our big game animals live in these areas.

Major goals of range management are to restore and maintain soil mantle stability and provide a continuous supply of adequate forage. These goals are generally, but not automatically, compatible with good watershed management. For example, in some situations a cover density of forage plants that will maintain itself and provide substantial forage may be too sparse to satisfy watershed protection needs. Trampling by grazing animals may compact the soil, reduce infiltration capacity, and increase surface runoff. In such situations watershed requirements may dictate a denser cover, less grazing use, shorter grazing seasons, or other measures.

A goal of big-game management is the maintenance of healthy herds in balance with habitat capacity. Another goal is the control of game populations and their movement to prevent damage to watershed cover and the soil itself. When these objectives are not met, watershed damage occurs and game herds also suffer.

Good range management and improvement measures usually improve watersheds. Adjustment of livestock and game numbers to the safely usable forage supply, control of grazing season, distribution of watering facilities, and most of the other management practices benefit both grazing and water resources. Seeding, shrub planting, fertilizing, terracing, contour furrowing, pitting, installing gully plugs and check dams, and other range improvement practices usually benefit water resources, for they increase the vegetal mantle, improve infiltration rates, provide better seasonal distribution of streamflow, and reduce floodwater and sediment damages. However, watershed considerations may extend the scope of the work, require some modification of techniques, or dictate changes in plans for post-treatment use.

In some instances where water values are dominant and are easily damaged, strict limitation or even elimination of livestock grazing and special efforts to control big-game use may be required because of the greater public benefits to be derived.

Most of the streams which provide opportunity for sport fishing originate or flow through forested lands, and the management of these lands affects both watershed management values and wildlife management values. Silt and other coarser sediments from eroding

[2] Forest Service, U. S. Department of Agriculture. Timber resources for America's future. Forest Resource Rpt. 14. 1958.

slopes and streambanks pollute water supply and often cause downstream damages. From the standpoint of fish habitat, sediment deposits frequently smother spawning beds, reduce aquatic life, fill resting pools, and reduce stream depth. It may also damage wildfowl and other wildlife habitat.

Removal of streamside cover of trees and shrubs is a possible means of reducing non-beneficial water losses, but it needs to be examined also from the wildlife management viewpoint: such treatment increases water temperature and this may be harmful or advantageous, depending on the original situation.

Recreation.—Experience of the past 15 years clearly demonstrates that the American people look to the outdoors for fulfillment of much of their rapidly growing desire for recreation. For example, in 1958 recreational use of the national forests totaled 68½ million visits. A rapidly increasing population, improved transportation, more leisure time, and increased recreational desire combine to indicate that this use will increase to at least 130 million visits within the next decade. Other public land administering agencies report similar experience. While recreational use is a management objective on public lands particularly, private landowners are also experiencing public pressure for recreational use.

On forest lands heavy recreational use is usually concentrated in small areas where it is difficult to maintain desirable watershed conditions with respect to plant cover, infiltration rates, and natural control of runoff. However, since these are small areas in comparison with the whole of the watershed, recreational use seldom creates serious watershed problems. If alternative sites are available, this kind of damage may be lessened by choosing the site least subject to damage.

Everywhere water is a powerful magnet which attracts recreation minded people to our forested lands. Therefore the land manager must consider recreational use principally with respect to quantity and quality of water needed, the environment in which use will occur, and the hazards of pollution or other impacts on downstream water supply. It follows that watershed and recreation objectives must be coordinated to insure that adequate recreational facilities are provided and that they are constructed and managed so as to protect both the recreationist and downstream water user.

Roads and highways.—Roads and highways now occupy several million acres throughout the forest lands. Yet even at present many otherwise usable forest areas are relatively unused because of lack of access.

Realization of our future needs for forest land resources and meeting other future needs for transportation facilities will require very great expansion of the present road systems. As applied to forest lands, this expansion will undoubtedly have its greatest effect on watershed values within the national forests. Here estimates[3] indicate that by the year 2000 forest highways will need to be increased by 45,600 miles and forest access and development roads by about 389,000 miles.

Assuming that a forest access road occupies roughly 8 acres per mile, several million additional acres of forest land will be disturbed by road building, and after construction hydrologic behavior of these lands will be greatly changed. Inherent in road construction are several elements and objectives which oppose the soil-water relationship objectives of watershed management.

These include (1) waterproofing the road surface itself, (2) quick drainage of the road surface, shoulders, and roadside ditches, (3) deep incision of the soil mantle, which often intercepts subsurface flow, (4) cut and fill slopes which, unless quickly stabilized, expose soil and subsoil to erosion, (5) artificial channels (roadside ditches) which intercept and quickly concentrate surface runoff from uphill slopes.

Reducing the damaging impacts of road construction on water resources and insuring against problem situations begins with road location and extends through planning, construction, and maintenance. It involves everyone from the transportation system planner to the bulldozer operator. The watershed manager must lead the way by appraising effects upon water resources and by aiding in the development of criteria, methods, and standards to prevent avoidable damage and obtain post-construction conditions of cover and water disposal which are acceptable for watershed management purposes.

Mining, oil, and gas production.—Minerals, oil, and gas are essential parts of our natural resource base and their production from forest and range lands will need to continue and probably expand as our country grows.

Mining and drilling operations pose a number of serious watershed problems such as the following:

1. Destruction or damage to plant cover.
2. Creation of erosion hazards such as access roads.
3. Sediment contributions to streams from strip pit spoil banks, and placers.
4. Waste discharge of acid, oil, or salt water into streams and lakes.
5. Destruction or long postponement of soil productivity by strip-mining operations.

Erosion hazards are often greatest during exploration and prospecting; such work usually covers extensive areas where control of operations and restorative treatment alike are difficult. Certain provisions of the laws relating to exploration and mining on public lands sometimes also complicate this phase of the problem.

[3] Forest Service, U. S. Department of Agriculture. A report on road needs in the national forests. 1959. Prepared in response to request of Senate Public Works Committee and Senate Report No. 1407, 85th Cong., on the Federal Aid Highway Act of 1958.

Perhaps the greatest watershed threats from mining and drilling operations are pollution of water supplies by sediment, and contamination by acid, oil, or salt water waste. State laws and regulations may or may not provide adequate safeguards. Water interests should be alert to such situations and take the lead in obtaining preventive or corrective treatment.

Other uses.—Several other forest and range land uses need to be coordinated with watershed management objectives. Pipelines, power transmission lines, airports, and wilderness areas need not be discussed in detail, but it must be recognized that they sometimes create watershed management problems. For example, an unstable pipeline right-of-way, a poorly built airport road, an overused wilderness pack train trail may be just as much a source of damaging sediment and floodwater as an overgrazed range or a poorly built logging road.

Meeting the country's future needs for water and the services provided by it means that many more water development and control projects will be constructed on forest and range lands at a cost probably reaching several billion dollars. Runoff and erosion conditions on tributary watershed lands may adversely affect the life or utility of these projects; hence watershed protection and rehabilitation may need to be intensified to adequately safeguard public investments and benefits.

As these projects are built, adherence to sound watershed management principles will be needed to minimize the damaging effects of disturbance of cover, soil, and streamflow resulting from construction or operation. In addition, such projects often modify existing land uses on adjacent lands or change them altogether. These changes may increase fire risks, accelerate runoff and erosion, or increase the hazard of water supply pollution or contamination.

Liaison and coordination between land managers and the builders of water development projects are constantly improving, but the growing needs and pressures for both forest and range products and water supply facilities dictate that the means of correlating land and water uses must be strengthened and intensified.

Rehabilitation of Damaged Watersheds

We need to pay more attention to the rehabilitation of damaged areas. In the course of our growth as a nation, a great deal of damage was done to the forest and range lands. The causes and consequences are now generally well understood, and although abuse of land and water resources and destructive wildfire still occur, it is quite improbable that our country would permit the widespread denudation and depletion of the past to be repeated. This is a reassuring conclusion, but we are still faced with the sorry heritage of many millions of acres of both public and private lands which are now sources of accelerated flood runoff and damaging sediment. Such areas must be repaired and their productivity restored.

Federal land-administering agencies, the Congress, agricultural leaders who work with private landowners, and a large segment of the general public have been aware of the nature and scope of this job for some time. Nevertheless, the application of remedial measures has been painfully slow. This is illustrated by the following examples of current accomplishment rates for a few of the principal needed measures which provide a better picture of the present status of watershed restoration.

1. Range reseeding. On lands administered by the Bureau of Land Management and the Forest Service about 23 percent of needed reseeding has been completed. The combined remaining job on these lands is estimated at 12,250,000 acres.

2. Reforestation. For the commercial forest lands as a whole, forest planting has increased fivefold in the last quarter century but as of 1959, about 83 percent of the job remained to be done.

3. Special measures for watershed protection. Little more than a start has been accomplished in the installation of measures such as contour terracing, pitting, water spreading, gully and channel stabilization, and erosion control on roads and trails. On land administered by the Bureau of Land Management and the Forest Service, accomplishment varies by measures from about five to less than one percent of estimated needs. More progress has been made on private lands, but accomplishments are still far short of total needs.

Important factors which have caused low accomplishment rates include the following.

1. Watershed protection values given lower priority than other current land uses.

2. Difficulties met in reducing or postponing other uses while rehabilitation measures were being established.

3. The relatively long period sometimes required for measures to become effective.

4. Lack of capital and small chance of early financial return on private lands.

5. Lack of economic criteria that adequately reflect long-deferred benefits or public values.

6. Deterioration of site quality so severe that restoration is physically difficult or extremely expensive.

7. Inadequate technical knowledge for the solution of particularly difficult problems.

These appraisals emphasize the need to materially increase the annual rates of watershed rehabilitation work if future needs for water and other wild-land resources are to be met and a higher degree of protection from flood and sediment damages achieved. It may also be necessary to increase and broaden the scope of public cost sharing for work on private lands that produce public benefits.

Improvement of Water Yields

Management of vegetation to alter streamflow behavior and increase usable water yields is probably the most intriguing prospect in applied watershed management.

Research has demonstrated on study plots and a few small watersheds that the vegetation on wild lands may be managed or modified to produce such results.

In regions of heavy snowfall, significant increases in water yield were obtained by opening forests in patches or strips.

In some places removal of riparian vegetation has produced significant gains in water yield. This practice also creates problems of establishing substitute species which use less water than those removed, the control of erosion on streambanks, preservation of suitable habitat for fish and wildlife, and maintaining the aesthetic values of streamside zones.

Increases in water yield have been obtained by converting cover from deep-rooted to shallow-rooted plants. This method appears to have application in parts of the chaparral, woodland, and marginal timber zones in the semi-arid West, particularly in areas having deep soils.

Research on the relationship between vegetation and water yields is new, and findings such as these seem to hold much promise but have been tested only on a very limited scale. It would be unwise now to begin extensive programs of cover manipulation on the presumption that research results in respect to water yield would be essentially duplicated. For example, runoff from upstream research plots and small watersheds in the West is often two to four times that from an entire river basin when similar units of area are compared. Very little is known about the relationship in water yields between large and small areas.

More pilot projects are needed to test broad-scale application of available knowledge. They will permit controlled testing of selected vegetative treatments as affecting water yields and quality and also provide opportunity to study the effects of these watershed practices upon the management and use of other resources.

While there is considerable evidence that forests and other wildland vegetation can be manipulated and management modified to increase yields of water, the vegetation will always have a primary role in contributing to soil stability, regulating streamflow, and maintaining water quality. Any system of management to reduce the use of water by vegetation for the benefit of downstream uses should be applied strictly within limits which do not jeopardize this primary protective function.

Other Factors Affecting Watershed Management

Forest and range fires.—The physical damages and the hazards to life and property created by uncontrolled fire on forest and range lands are well known. In many watersheds wild fire is the most serious threat to water values. After fire, even moderate storms may severely erode the burned area and produce devastating floods that carry silt and debris to developed areas below. The usefulness of water for domestic and industrial purposes is often seriously impaired. Soluble salts leached from the ash may make the water supply temporarily unfit for use. Ashes and eroded silt damage water collection, conditioning, and distribution systems. They also reduce the effectiveness and increase the costs of purification treatments.

These results are not uniform throughout the country because the potential for damage varies watershed by watershed. For each situation watershed management objectives must be appraised in establishing fire prevention and control objectives and in providing the facilities to meet them. Fire control planning usually recognizes the practical limitations of prevention and suppression efforts in terms of allowable burn. These guidelines are useful when applied at national, regional, or state levels. However, they often need to be adjusted for individual watersheds since size and locale of individual fires may be important factors affecting flood runoff and sediment discharge. It is a watershed management job to supply the hydrologic criteria by which these factors are weighed.

Fire control activities often unavoidably create runoff and erosion hazards. Corrective measures should be promptly applied in firebreaks, protection strips, and fire roads as a concluding phase of the suppression job.

Preservation of soil stability and the prevention of damaging floods or pollution of water supply should be the immediate and dominant aim of post-fire treatment. Situations involving a large potential for erosion on the watershed, high water values, a severe threat of flood damage may justify special measures such as seeding of quick-growing plants, contour terracing, or debris catchment basins. In all instances post-fire treatments and uses such as timber salvage, resumption of grazing, seeding, replanting, or natural recovery should be considered in the light of probable effects upon soil and water resources.

The risk that man-caused fires will start will be increased as the number of visitors and users of wild lands increases. Expanding population, industrial development, more water development and control structures, and more intensive use of the land also mean that more people and property will need protection from damage caused by floodwater and sediment or impairment of water supplies following fires.

Insect and disease control.—Forest and range pests frequently cause serious and widespread damage to resources such as timber and forage but generally do not directly create watershed problems. Of course the killing of forest stands by epidemic attacks may greatly increase the hazard of fire and subsequent watershed damage. Further, the measures used in insect and disease control may pose threats to watershed values.

Control projects are often carried out under emergency conditions and in the rush to get the job done within inflexible time limits, watershed protection requirements may not receive enough attention,

especially in access road construction and timber salvage operations. The emergency nature of some pest control projects should not be held to justify relaxation of watershed protection standards.

Landownership.—Although precipitation, within its natural patterns, falls impartially on all land, ownership objectives as expressed through management have great effects upon the character, quality, and timing of water yields.

Water, as a resource from wild lands, is peculiar in that a very large part of the direct benefits from water use are realized at a distance, often many miles, from the watershed which produced it. This relationship is true also with respect to floods, pollution, sediment, or other forms of water damage. There is a basic problem in reconciling ownership objectives on watershed lands, which are aimed at the use of other natural resources, with public and semipublic needs for usable water or protection from water-caused damages.

People concerned with watershed management must accept the fact that the economic and social stimuli which determine resource management objectives and ownership purposes are not the same for both public and private land. This is especially true with respect to such fundamental factors as profit motive, time preference, the cost of capital, facilities for research, scope of knowledge, and sense of public responsibility.

To illustrate this briefly, downstream water interests cannot expect the private owner of deteriorated forest and range land to restore it to good hydrologic conditions when he cannot finance the necessary work or when his potential returns over a reasonable period will not at least equal the cost of doing the work.

From the standpoint of off-site water interests, public ownership of watershed lands is sometimes advocated and in some cases such as municipal watersheds or very critical flood source areas this may be the only satisfactory solution. On the other hand, private ownership of land is a basic element of our national philosophy which we must preserve.

According to recent estimates, forest and associated range lands in continental United States including Coastal Alaska total about 644 million acres, of which about 417.4 million acres or 63 percent is privately owned. Though many watershed problems on public lands remain unsolved, a major challenge to watershed management is to find ways to bring the diverse objectives of the private owner of watershed lands and downstream water interests together into a mutually beneficial, multipurpose management program. This may require greater attention to cost sharing between public agencies, water interests, and the private landowner for watershed treatment which produces off-site benefits.

Supporting Programs

Education.—There is still much to be learned about soil-water-plant relationships and the ways by which these relationships can be modified by management practices. However, a great deal of information is already available to guide foresters and other land managers in applying sound principles of watershed management. It has been rather bluntly said that "we know a better job than we are doing," and for the watershed lands as a whole this criticism has some validity. While our institutional processes are partly at fault, the main explanation is that existing watershed management knowledge has not yet been transmitted to enough watershed owners and managers in ways which they can understand and are willing to accept.

On the publicly owned lands, managerial competence in watershed management has not yet been generally attained to a degree commensurate with the importance of wild-land water resource values. This is a situation which can be corrected without great difficulty and by organizational means already available. It will require more emphasis on watershed management in college and university curricula and much more attention to in-service training by the public land managing agencies and by other state and federal agencies who provide technical advice and services to private landowners.

Achieving widespread understanding, acceptance, and application of sound watershed practice by owners and operators on the privately owned forest and range lands is a much more difficult and serious problem. But it will need to be solved somehow if the country's future needs for water and other wild-land resources are to be met.

The problem is made difficult by certain factors which include the following:

1. The large number of ownerships and the predominance of small ownerships. For example 4½ million small private owners control 265,000,000 acres or over half of the nation's total commercial forest land. About 86 percent of the small ownerships are less than 100 acres in size.
2. Heterogeneous ownership purposes.
3. Farm enterprises that give little or no attention to farm forestry.
4. Short tenure and absentee ownership.
5. High percentage of land in poor condition and producing low income.

These and other factors are discussed and appraised in *Timber Resources for America's Future* from the viewpoint of timber resources, but they are of at least equal concern to watershed management. In fact, they may even be more significant because of the off-site nature of many water uses. They deserve serious consideration by state and federal agencies which provide technical advice, financial aid, or other services to private landowners.

Research.—Many of the problems facing watershed managers have developed because we have not known enough of the basic facts about the water resource or about water, soil, and plant relationships as these are affected by land use.

Insufficient knowledge of the practical applications of known facts has magnified these problems.

At the present time research in these fields is unable to fully meet current demands for information to guide public water programs and land resource managers. Meeting increased future demands for water and other wild-land resources will require that watershed research, both basic and applied, will need to be increased several fold and expanded in directions which have heretofore received little attention.

Identification and description of the many watershed problems which should be explored by research methods is an extensive and detailed subject which is not attempted in this discussion. However, there are a number of broad lines of study which need increased attention. These are prerequisite to satisfactory integration of watershed management objectives and other uses of forest and range lands. They include but are not limited to the following:

1. Atmospheric phenomena such as solar energy, air temperature, wind, and humidity which affect the hydrologic cycle.
2. Social, economic, and legal principles for water resource use.
3. Development of better economic criteria for measuring the costs and benefits of watershed management and flood prevention.
4. Improved techniques for measuring water yields and water use by plants.
5. Control of water lost by evaporation and transpiration.
6. Improving water yield and seasonal distribution of streamflow by manipulation of plant cover.
7. Means of improving the efficiency of on-site water use by plants.
8. More comprehensive and complete inventory-type data regarding climate, soils, plant cover, and water yields.

A Summing Up

The whole issue of watershed management is complex and difficult. There are no simple solutions. Our satisfaction with present accomplishments diminshes when we think of what yet needs to be done. But the job ahead need not dismay us; it can be done, and somehow must be done if the nation is to remain strong and prosperous.

There are a few general directions in which we should move. As the population and economy and thus the demand for water expand rapidly, it is plain that more attention will have to be directed to the watershed and its management. We need to think, talk, plan, and practice more watershed management. At the same time we have to keep in mind other forest and range resources that cannot be appreciably sacrificed in favor of water. We should formulate a clearer national water policy and thereby achieve wider understanding of the issue among all the people. Only through greater understanding can we expect the support necessary to stepped-up action. Because so much of our wild lands are in small private ownership, we need to find some way to enlist the cooperation of millions of small landowners.

Regardless of the difficulties, water is the most important natural resource issue before us as a people. Each of us is vitally involved, and therefore each is obligated to practice and promote more intensive watershed management at every opportunity. The health of our watersheds can well determine the economic health of our communities and our nation. With well managed watersheds we can grow in strength and prosperity.

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Editor's note.—The JOURNAL is indebted to Dr. Robert E. Dils, College of Forestry and Range Management, Colorado State University, Fort Collins, for his efforts on behalf of this special issue on the subject of watershed management. Dr. Dils was serving as associate editor for watershed management during its planning and manuscript preparation stages.

Watershed Management Research in Southern California's Brush Covered Mountains

J. D. Sinclair

MORE THAN eight million of southern California's residents live in metropolitan centers and intensely developed valleys fringing the Pacific Ocean. These people have much at stake in the rugged mountains of the coastal ranges that separate them from desert areas to the east. The mountains are the source of two-thirds of their water even though much is imported hundreds of miles. These mountains can also be the source of disastrous floods, and the effectiveness of vital flood control works can be impaired by debris from the mountains.

The coastal ranges include some of the most unstable terrain in the world. The San Gabriel Mountains have been subjected to major uplifts and intensive faulting, and the fractured rocks weather rapidly (*13*). Soils on the steep slopes are generally shallow and very erodible. The dominant brush vegetation is highly flammable during dry seasons. As a result wild fires are a major land management problem. Runoff and erosion often are greatly accelerated from fire-denuded slopes, causing debris-laden floods even during moderate storms. Furthermore, intense storms are to be expected in winter months. Record rainfalls have been 0.65 inch in 1 minute, 11.50 inches in 80 minutes and 26.12 inches in 24 hours. These conditions form the basis for some of the most difficult and challenging watershed management problems to be found anywhere.

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San Dimas Experimental Forest

To aid in the solution of these problems the San Dimas Experimental Forest was established by the Forest Service in 1933 as a center for watershed research (*9*). The forest, an area of 17,000 acres, is situated on the southern, brush-covered slopes of the San Gabriel Mountains, about 30 miles northeast of Los Angeles.

The broad objectives of the work undertaken at San Dimas are (1) to learn what happens to rain falling on brush-covered watersheds in terms of water yields and losses, and how water and soil movement are influenced by watershed features such as vegetation, soil, and geology; (2) to apply this information in the management of watersheds to increase yields of good water and decrease flood flows and erosion.

Planning and constructing the necessary research installations on the San Dimas area was a major undertaking made possible by assistance received from several emergency agencies in the 1930's.

Facilities included:

1. Three hundred twenty raingages placed on contour trails to measure rainfall and its variations in the rugged mountains.

2. Seventeen streamgaging stations (Fig. 1) built to measure runoff from watersheds of 35 to 8,400 acres; seven of the smaller watersheds are equipped with basins to measure sediment.

3. One of the world's largest lysimeter installations, constructed to compare the influence of different native plant species on water yields and losses (*2*).

4. Eighteen 1/40-acre plots installed on slopes to measure surface runoff, erosion, and evapotranspiration under different types and ages of chaparral and grass cover (Fig. 2). Other plots were established in a pine plantation.

Accomplishment highlights.—Improved techniques and new instruments have come from research at San Dimas as well as information about the fundamentals of watershed performance. For example, errors were encountered in measuring rainfall on steep mountain slopes with conventional raingages. A gage with its orifice tilted parallel to the slope upon which it is placed proved to sample rainfall more accurately, especially during intense storms, than a conventional gage with horizontal orifice (*4*).

The San Dimas flume, a self-scouring streamgage, was developed to measure streamflow carrying bedloads ranging from silt to boulders when it was found that other measuring devices became choked with the debris (*14*).

The Colman fiberglas soil moisture instrument (*3*) made possible accurate and frequent measurements of soil moisture to determine water movement into and through the soil as well as losses by evapotranspiration.

Lysimeter results show that infiltration of rainfall into the soil under grass, shrubs, and pine varies from 2 to more than 3 times that into bare soil (*11*). Surface runoff, on the other hand, was correspondingly greater from the bare soil. Evapotranspiration during each dry season exhausted all avail-

FIG. 1.—San Dimas flumes in tandem measure flood peak and lower flows carrying bedload. Low clear flows are diverted and measured in weir at left.

FIG. 2.—Vegetation converted from brush to grass on test plots. Brush remains on other plots at right.

able moisture in the 6 feet of soil under the shrubs and pine. Seepage (groundwater yield) occurred only under grass during drought years and during a very wet year was greatest under this cover.

Findings from the lysimeters have been substantiated under more natural field conditions by plot results. In plots covered with dense chaparral, and others with Coulter pine, practically all the available moisture in soil 10 to 12 feet deep was lost by evaporation during each dry season. Under grass cover maintained on similar plots, available moisture in the soil was exhausted to depths of only about 3 feet, leaving soil moisture in storage at deeper levels. This extra storage occurred only when a pure grass cover was maintained; when deep-rooted weeds were permitted to invade the grass site, all available soil moisture was lost to depths of 10 feet (*1*). In a followup study, after the brush on one set of plots was killed with hormone sprays, water losses from the soil were less than half those when the brush was living.

The detailed records of rainfall and streamflow accumulated since 1934 at San Dimas have provided information concerning the hydrologic behavior of watersheds. In one instance, records from 875-acre Monroe Canyon, supplemented by soil moisture and rainfall interception data, were used in studying rainfall disposition on this well-vegetated watershed. Annual rainfall averaged 27 inches during the 15-year study period. Fifteen inches, or more than half the rainfall, was lost annually by evapotranspiration. Of the remaining 12 inches, streamflow amounted to only 3 inches, and 9 inches was considered groundwater yield (*1, 8*)—emphasizing the porosity of San Gabriel Mountain watersheds, and the necessity to account for ground-water yield as well as surface flows.

The effects of fire on streamflow and erosion were evaluated after the brush on ⅓ of a 1,500-acre San Dimas watershed was burned in 1953. Rainfall and streamflow records from the burned watershed and a similar unburned watershed,

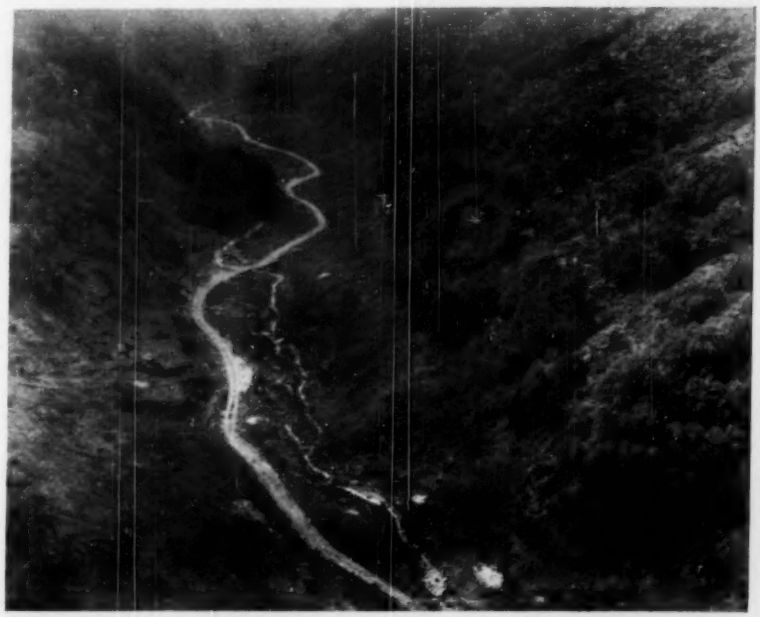

FIG. 3.—Monroe Canyon bottom cleared of woodland-riparian vegetation.

before and after the fire, showed that the first flood peak, bulked with debris from the fire-damaged watershed, was increased at least 68 times its normal. Erosion was accelerated nearly 30 times the average annual rate (*10, 12*).

Applied watershed management.—Last year, with a great deal of cooperative help from the State of California Division of Forestry and the Los Angeles County Fire Department, tests of brushland watershed management to increase water yield were started on two of the San Dimas watersheds (*5, 6, 7*). Thirty-eight acres of oak woodland-riparian vegetation along the main channel of 875-acre Monroe Canyon have been cleared (Fig. 3). Tree stumps were poisoned and phytocides applied to the cleared area to prevent new growth of shrubs and deep-rooted weeds and thus to favor the development of a grass cover. Volfe Canyon, an adjacent and comparable watershed of 740 acres, serves as the untreated control.

Past records have shown that streamflow yields from Monroe and Volfe were usually about the same, but Monroe's flow for the first test year after treatment was 70 acre-feet—30 feet more than predicted if the canyon bottom trees and shrubs had not been removed. Effects of the canyon bottom clearing on erosion have been negligible during two moderate winters. Changes in the channel are being checked by surveys in both Monroe and Volfe Canyons.

In the second test, 40 acres of brush on side slopes with deep soil in 100-acre Bell Canyon Watershed No. 2 have been sprayed with phytocides to kill the shrubs and favor the natural establishment of a grass cover. Two applications of chemicals were made by helicopter, the first in April, 1958 and the second in May, 1959. A good leaf kill has resulted from each spraying but much of the brush is still alive. Another spraying is planned for this spring. An adjoining 62-acre watershed serves as the untreated control. Soil moisture measurements are being made to compare evapotranspiration losses on treated and untreated slopes. Although there is evidence of some increase in streamflow from the treated watershed the effects of the treatment have not yet been evaluated.

These pilot tests are beginning to provide information required for the effective management of brushland watersheds. More applied studies are needed as well as basic laboratory and field studies, especially pertaining to soil and plant physiological phases of watershed management.

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Watershed Management Research in the Southeast

John D. Hewlett
and Louis J. Metz

RESEARCH to determine the effects of forest vegetation and land management practices on the components of the water cycle are carried out by the Southeastern Forest Experiment Station primarily at two locations. Most of the work has been done at the Coweeta Hydrologic Laboratory, located in the mountains of North Carolina in the region of maximum rainfall in the eastern United States. At the Union Research Center, in the piedmont of South Carolina, studies have been oriented toward the problems of rehabilitation of depleted watershed lands. Also, rather intensive studies of soil moisture have been made at this location.

The development of the research program at Coweeta reflects to some extent the evolution of forest hydrology in general. Large-scale field treatments to determine the effects of vegetation management on streamflow were begun in an era of great concern over our natural resources. The use of entire watersheds, carefully gaged for several years before treatment, to demonstrate the influence of the forest on components of the water cycle has led to newer ways of looking at land management problems.

The original rain- and streamgage system on the 5,600-acre tract of mountain land at Coweeta was constructed during the years 1934 to 1940. There had been much speculation about the influence of vegetation on streamflow, following the Wagon Wheel Gap experiment in 1911, but few worthwhile records had been collected to document the theory that forests consume much water while providing protection to watershed lands. Consequently, a primary objective in the beginning was to observe the seasonal behavior of streams from forested watersheds. During the early years annual hydrographs were compiled, seasonal comparisons were made among watersheds during normal and storm periods, and the water balance of the forest was calculated. Gradually, the annual patterns of water supply, consumption, and delivery were outlined in this area of deep soils, high rainfall, and dense forest cover.

By 1940 the backlog of information on local stream behavior was large enough to begin studies of forest influence on streamflow. A series of cover-type changes, ranging from complete clearcutting to removal of only portions of the forest vegetation, were planned and executed during the next decade. From the first records, the treatments indicated that it was possible to alter streamflow significantly in humid climates by drastic changes of the vegetative cover. The results of these studies have become part of the background of watershed management research, and are too well-known to dwell on here.

At the same time, treatments of a more practical nature were being tested on another series of watersheds. In line with the concern over the destruction of forest soil and the sedimentation of mountain streams by abusive forest and agricultural practices, efforts were made to demonstrate the deterioration of watershed values under planned abuse. Mountain farming, grazing, running cattle in the woods, and poorly managed logging were clearly shown to be destructive on watersheds of the Appalachian Mountains unless done with more care than is usually employed nowadays.

These demonstrations led to studies during the last decade of the recovery of depleted watersheds under protection and proper management. Vegetative measures for reducing storm runoff and erosion have proved very successful in these continuing studies. During this period, watershed stabilization research was extended to the Union Research Center in the piedmont of South Carolina, where the rehabilitation of eroded land in a troublesome area of poorer soils and lower rainfall has been studied on several small watersheds.

Throughout these years, techniques were being developed for conducting studies in forest hydrology. The usefulness of different types of weirs and rain gage installations, various methods for treating and comparing watersheds, and the application of hydrograph analysis to small streams were among the many contributions of Coweeta to the field of forest hydrology.

Basic records of rainfall, streamflow, and other factors pertinent to the study of the water cycle on unit watersheds continue to accumulate in the Coweeta files. The value of such long-term records, when dealing with weather factors, cannot be seriously questioned. Portions of Coweeta data have been

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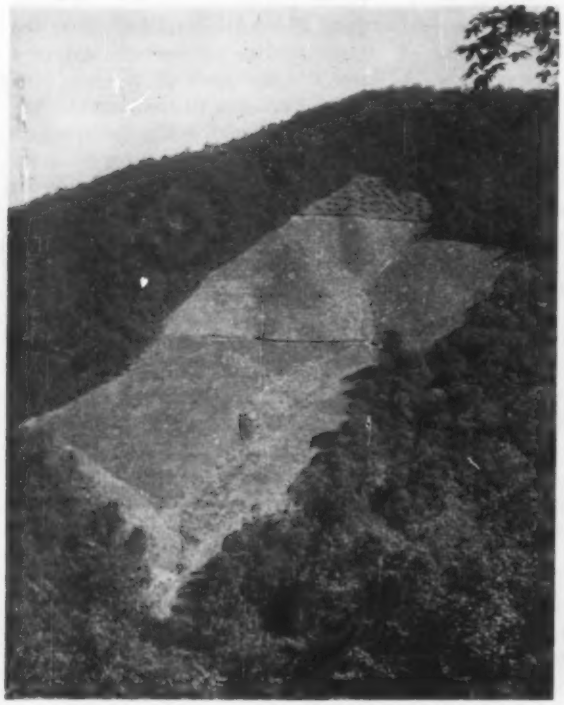
used in many ways: to check theories of forest water consumption, to illustrate facets of forest ecology, to provide runoff estimates for neighboring areas, and to suggest practical systems for management of municipal watersheds. The files constitute what is perhaps the longest and most thorough hydrologic record on small mountain watersheds now available. To make these records more usable, means are being employed for simplifying the compilation and summarization of the data. A portion of the stream records have been put on IBM cards for electronic computation, and similar treatment of additional data is planned.

Most of the Coweeta data has come from what is referred to as the "unit watershed approach," implying the calibration and subsequent treatment of the entire drainage area above a gaging station. The great advantage of the method is that streamflow is the net effect of many complicating factors in operation on the watershed. Unfortunately this is also a disadvantage; costly experiments constitute only single observations of the result, which may be different if the treatment is carried out at another time or on another watershed. The method has proved valuable, nevertheless, in setting goals for management and research and continues to be used at Coweeta and elsewhere.

A current series of watershed treatments at Coweeta is designed to determine the gross effects on water yield and regimen of four widely-differing types of vegetation, in an effort to provide some answers to long-standing questions about the comparative value of various possible types of watershed cover. In this test, not to be completed for another 10 or 15 years, native hardwood cover will be compared independently with a purely coniferous cover (white pine), grass cover, and shrub cover with the overstory removed. Two watersheds, one facing north and one south, have been planted to white pine, and another is substantially converted to grass (Fig. 1). In addition to this work, studies are underway at Union to determine the use of soil moisture by several densities of pine stands.

As experience with unit watersheds has accumulated from various parts of the country, appreciation for the complexity of watershed behavior has grown. Variations in results have led to the conviction that a clear picture of forest influence on streamflow will emerge only with better understanding of the basic processes involved in the water cycle. Unit watershed treatments must now be supplemented by greater knowledge of the mechanics of water supply, storage, evaporation, and runoff. The current program at Coweeta and Union is aimed at more fundamental understanding of the behavior of water within the watershed.

Coweeta watersheds, because of their small size, steepness, and sharply defined boundaries, have always proved useful for conveying visual impressions of the nature of watershed processes. These processes cannot easily be divided into separate problems; however, four overlapping fields of study have gradually emerged. They may be roughly equated with the behavior of water in the soil, the



Left

FIG. 1.—A 22-acre watershed undergoing conversion from hardwood forest to grass. Changes in streamflow will be measured by a weir at the bottom of the clearing.

Below

FIG. 2.—The neutron-scattering apparatus for measuring soil moisture. It is shown being used in the South Carolina piedmont to measure soil moisture to a depth of 16 feet.

plant, the atmosphere, and the stream channels. Research is now organized along these lines.

Soil investigations have long been a part of hydrologic research at both Coweeta and Union. Most early work centered around gravimetric soil moisture sampling, as well as bulk density, pore space, and percolation determination for evaluation and comparison of soil hydrologic properties. In addition to this work, more recently developed methods for soil moisture measurements are now being applied to the problem of soil moisture movement and distribution in the profile. Still one of the most puzzling components of the water cycle, soil moisture comprises the bulk of stored water in mountain watersheds. Studies of sub-surface drainage on slopes, involving the use of large soil models as well as field observations, are promising to throw some light on soil moisture as a source of base flow in streams. Other studies, located chiefly at Union, are aimed at determining quantities and variability of moisture in different types of soil, with the ultimate purpose of developing improved techniques for measuring evapotranspiration and drainage losses from soils. Recently developed neutron-scattering devices for measuring soil moisture are proving useful in these studies (Fig. 2).

In recent years the role of vegetation in water losses from land areas has been eclipsed by energy balance considerations, in which plants are regarded as passive agents in the evaporation of water from their tissues. However, there is still much evidence that plants, through structural as well as physiological peculiarities, have considerable influence over rates of transpiration. One neglected area of research in forest hydrology has been the study of the water economy of forest trees and shrubs. An effort is being made at Coweeta to relate the moisture content of leaf tissue to site and water consumption potential of different trees.

Solar radiation measurements have recently been added to the customary records of air, soil and water temperature, relative humidity, wind speed, and evaporation at Coweeta. These records are part of an effort to evaluate the application of energy balance theories to calculation of evaporation from forest land. Present indications are that the energy balance in mountain forests is far from a simple surface phenomenon, as is sometime postulated for level crop lands. Calculations of relative percentage of radiation received by opposing slopes are providing some basis for further research on the influence of aspect and slope on water losses to the atmosphere.

On the average, 128 storms of all sizes occur each year on the watersheds at Coweeta. The storm hydrographs of many storms consist primarily of channel interception; in no storms have significant amounts of surface runoff been observed. The make-up of the average storm hydrograph has been under study since the early 1940's, when the theories of the unit hydrograph were first applied to small watersheds. A thorough understanding of the source of the various components of the storm hydrograph will be basic to future efforts to control stormflow by vegetative means. Further work along these lines is planned using the accumulated records from Coweeta streams.

Since we cannot, at least so far, have much control over precipitation, the principal job of watershed research is to learn how to utilize the water that falls to the ground to the fullest advantage. As more information accumulates about principles of watershed behavior, it will be put to practical tests on watershed lands of the Southeast. Logging studies on pilot areas in the mountains have already provided examples of how watershed lands can be better managed in terms of multiple use objectives. And rehabilitation methods worked out by research in the piedmont are finding many applications on depleted lands of the region. Continued research and application of research findings is a must if we are to make optimum use of our water resource—one of the most important resources we get from forested lands.

Watershed Research on the Fraser Experimental Forest

L. D. Love and B. C. Goodell

THE Fraser Experimental Forest is located in the Rocky Mountains of Colorado, about 65 miles northwest of Denver and 5 miles south of the town of Fraser. It has an elevation range of 9,000 to nearly 13,000 feet and is representative of much of the high, water-yielding lands of the central Rocky Mountains where melting snow forms the principal source of four major rivers. Dense stands of Engelmann spruce, subalpine fir, and lodgepole pine cover most of these headwater areas, but at higher elevations alpine tundra and rock surfaces are extensive.

Although a prime source of water, the Colorado Rockies receive but moderate amounts of precipitation. On areas above 9,000 feet, annual precipitation does not average more than 30 to 40 inches and decreases rapidly with lower elevation. Of the 30 to 40 inches, 60 to 80 percent occurs as snow, which begins to persist on the ground during October and accumulates with little or no loss by melting until the spring thaw in April, May, and June.

This snowpack and its environment, particularly its forest environment, has been a subject of some study at the Fraser Experimental Forest for 20 years. First came observations in natural stands to see how forest type and canopy pattern affect snow accumulation. Next came plot studies involving thinnings and harvest cuttings and measurements to determine the effects of these treatments on the winter accumulation of snow, spring snowfall and rate of snowmelt, summer rainfall, and evapotranspiration of soil moisture. The final step in this logical sequence is the manipulation of timber on complete watersheds and observations of the effects on streamflow. Results from one pair of watersheds are currently being obtained and other watersheds are under study preliminary to treatment.

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FIG. 1.—Clearcut strips, Fool Creek watershed, Fraser Experimental Forest, Colo.

Plot Studies

One of the earliest studies at Fraser made comparisons among an open field, a stand of aspen, and a stand of young lodgepole pine with respect to snow accumulation and spring and summer precipitation (*1*). Intensive and periodic sampling with a snow tube was employed to measure snow accumulation. Precipitation gages were used to measure spring snowfall and summer rainfall. The snowpack was least under the dense pine canopy and was 14 and 30 percent greater, respectively, within the open field and under the aspen. The influences on spring and summer precipitation were similar but with non-significant differences between the aspen and grassland.

A second study in natural stands dealt with the relation between snow accumulation and size of forest openings (*7*). The study was made in a stand of mature lodgepole pine where heights averaged 80 feet and openings up to 60 feet in diameter existed. Least snow was found under dense groups of trees, and the deepest snow was near the center of the largest openings. From the edge of the canopy outward toward the center of the opening, the water equivalent of the snowpack increased by about 0.07 inch for each foot of horizontal distance.

These studies were intended to

give clues as to the effects that would be produced when forest stands were harvested for timber or thinned to stimulate tree growth. Upon completion of the studies, tests of different intensities and patterns of timber cutting in stands of different ages and composition were initiated.

The effects of harvesting timber from a mature stand of lodgepole pine was one of the first of these experiments (*8*). The stand averaged about 75 feet in height and 12,000 board feet per acre. Twenty plots, 8 acres in size were used, four intensities of cutting applied, and comparisons made with uncut plots. The residual volumes per acre remaining under the four intensities were: 6,000, 4,000, 2,000, and zero board feet in trees of sawlog size, 9.5 inches d.b.h. or larger.

Measurements of winter snow accumulation, spring and summer precipitation, and summer losses of soil moisture over a 3-year period showed that the commercial clearcutting increased the water available for streamflow by 31 percent, or from 10.3 to 13.5 inches per year. The lesser intensities of cutting produced proportionately less increases in available water.

Although the accumulation of snow on the cut plots was considerably greater than on those uncut, the snow disappeared from all plots at about the same time. This indicated that rates of snowmelt were accelerated by the cutting and the reduction of canopy shading.

Measurements of growth and mortality of the residual stand were also made and revealed that mortality equaled or exceeded growth on all of the cut plots except those cleared of all sawlog size trees and that the principal cause of mortality was windthrow. This result, together with that from the hydrologic measurements, led to the conclusion that the clearcutting of mature lodgepole pine is the most desirable method of harvesting.

In another study, a stand of lodgepole pine 35 years old and averaging 4,400 trees per acre was thinned (*3*). Two intensities of thinning were applied. The heavier thinning reduced the number of trees per acre to 630 by reserving only the better trees spaced about 8.5 feet apart. Under the lighter thinning, an average of 2,000 trees per acre was left by the practice of cutting a 16-foot diameter hole around each of the 100 best trees per acre spaced about 21 feet apart.

In terms of water equivalent, the heavier thinning increased the winter snow accumulation by 2.3 inches or 23 percent; the lighter thinning increased it by 1.7 inches or 17 percent. The thinning also increased the average rate of melt by 0.11 inch per day or from 0.26 to 0.37 inch. There was no significant difference in the melt rate between the two intensities of thinning. Neither thinning produced any detectable change in the amount of summer precipitation reaching the soil under the slash. On the more heavily thinned plots, the diameter growth of the residual stems was increased by 50 percent or from .10 to .15 inch per year. On the more lightly thinned plots, diameter growth was accelerated from .09 to .12 inch per year or by one-third.

The effects of different patterns of timber harvesting were the subject of another plot study made in a mature stand of Engelmann spruce and subalpine fir averaging 18,000 board feet per acre and lying on a steep, north-facing slope. On each treated plot the harvesting left the same 40 percent of the original volume but the pattern differed from plot to plot. On one plot the harvesting left uncut strips 66 feet wide alternating with equal strips from which all trees 9.5 inches d.b.h. and larger had been removed. On another plot, harvesting was by group selection whereby half of the plot area was cleared of mature timber by making openings 66 feet in diameter. From each of these plots, an additional 10 percent of the original volume was removed in a salvage cutting from the uncleared area. On a third plot, the cutting was by individual tree selection and the residual stand approximated a heavy shelterwood.

Snowpack comparisons among these plots and an untreated plot, over a 3-year period, indicated that the timber harvesting caused an average increase of 22 percent in the winter snowpack or an increase from 12.4 to 15.2 inches of water equivalent. There was no difference in the snowpack among the patterns of treatment, but the rate of spring snowmelt was slightly lower on the plot cut in a group-wise pattern, where shading from sunlight was more complete (*5*). The results indicated that on such a slope the snow accumulation was not related to the pattern of timber harvesting but only to the volume of timber left.

Growth and mortality observations of residual trees revealed that in these factors, as well as in relation to snowmelt, the group selection pattern was slightly the best. However, because of the difficulty of application of the method, the alternate strip clearcutting method was chosen for watershed studies at the Experimental Forest.

Watershed Studies

Because all of the foregoing studies were on plots 8 acres or less in size, there was no opportunity to translate the effects on the snowpack directly and con-

Table 1.—Actual Versus Predicted Water Yield From Fool Creek in Post-Treatment Years

Years	Predicted yield	Actual yield	Actual yield minus predicted yield
	Area inches		
1956	11.4	15.6	4.2
1957	19.6	23.0	3.4
1958	11.4	13.5	2.1
1959	10.5	13.6	3.1

clusively into terms of streamflow. Early in the sequence of plot studies a watershed study was initiated to test the plot results (*4*), and other watersheds have been added in more recent years to enable further testing.

The gaging of Fool and East St. Louis Creeks was begun in 1943 and continued without the logging of either watershed until 1954. The two watersheds are contiguous. That of East St. Louis Creek has an area of 1,984 acres. Fool Creek, the watershed finally treated, has an area of 714 acres of which 550 acres, or 77 percent, was in a dense mature stand of lodgepole pine, Engelmann spruce, and subalpine fir.

Following completion of a 12-mile road network, the logging of Fool Creek was started in 1954 and completed in 1956. The pattern of cutting was one of alternate clearcut strips of different widths, 1, 2, 3, and 6 chains, running normal to the contours (Fig. 1). The division of the watershed into four compartments permitted the replication of the four widths of strip and may permit the evaluation of strip width and orientation as they affect snow accumulation, snowmelt, windthrow of the residual stand, and regeneration. From the clearcut strips all live trees 4 inches d.b.h. and larger were removed. Fifty percent of the commercially timbered area of the watershed or 40 percent of the entire watershed was so cleared.

Although the final 20 percent of timber harvest was not completed until the summer and fall of 1956, that year has been classed as a post-treatment year for preliminary reporting. This gives four years of record to show the effect of the harvest. For each of these years, the excess of actual water yield over that predicted from the comparison with East St. Louis Creek is shown in Table 1.

Most of the increase in yield has occurred during the spring freshet period of May and June, but there has also been a small increase in the summer and early fall months. Each year the early rise of Fool Creek is more rapid than formerly, and in 3 years the spring peak has been higher than it would have been had the timber not been cut. However, in 1957, the timber removal combined with a particular weather pattern to cause a peak appreciably lower than predicted by comparison with the behavior of East St. Louis Creek.

An illustration from a larger watershed of a similar influence on streamflow was obtained from a comparison of two watersheds farther west in Colorado on one of which there was extensive killing of spruce by bark beetles (*6*). On the 762 square mile watershed of the White River above Meeker, beetles killed 26 to 80 percent of the timber on a 226 square mile area. The watershed of the Elk River, 60 miles to the north was unaffected by beetles. A comparison extending before and after the beetle epidemic revealed that the annual flow of the White River was increased by 22 percent. The dead and needle-free trees could intercept relatively little snow and rain, nor did they use water in transpiration. Apparently the effect was similar to that obtained on the Fraser Forest through logging.

Snowmelt and Streamflow Studies

A cooperative investigation with the Bureau of Reclamation was conducted during the snowmelt seasons of 1947 to 1953 inclusive (*2*). Analyses of the runoff hydrographs showed the major importance of long-term recession flows. Relations were developed between the daily snowmelt hydrograph and the melt-causing meteorological factors that lead to techniques for forecasting the shape of the hydrograph.

The concepts developed have been used widely in the computation of design floods for spillway capacities of a large number of dams. The technique of forecasting runoff has been used for reservoir operation and river control. The recognition of the interaction of solar radiation and wind movement has led to the initiation of new experiments on the influence of forest manipulation on water yields from drainage basins.

Future Research

Other work currently under way at Fraser has as its objective a better fundamental understanding of the interrelationships among forests, microclimate, and snow. Some understanding has been obtained from plots. Watershed studies have confirmed that forest manipulation can significantly affect streamflow. Needed now is further knowledge of cause and effect relationships so that forest manipulation can be directed toward the attainment of specific streamflow objectives such as increasing annual yield, prolonging the spring freshet, or reducing the magnitude of the spring peak. Studies of the effect of forest type, age, and composition on the solar radiation balance over snow and ground are being started. Means of surveying and evaluating the shading action of forest canopies are being explored. The measurement of other weather variables is being extended. With these additions to basic knowledge, watersheds now under calibration will be used to test new hypotheses.

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Watershed Management Research in Arizona and New Mexico

H. G. Reynolds

WATERSHED MANAGEMENT research in Arizona and New Mexico began on a modest basis about 1910. By 1935 research in soil stabilization and reduction of sedimentation was greatly increased. More recently, the possibility of augmenting water yields has received more and more emphasis. This paper briefly discusses current watershed management research of the U. S. Forest Service in the Southwest.

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General Problem

With the possible exception of the Great Basin, the Southwest is the lowest surface-water-yielding region in the United States. Moreover, nearly all surface water flows are now impounded and are serving some beneficial use. Procurement of additional surface water supplies are thus dependent upon watershed development or acquisition of water from other sources.

Demand for water is growing in the Southwest. Also, demands are developing for other products from the watersheds, such as lumber and other wood products, forage, game, and recreation.

In general, best water-yielding lands are located at the higher elevations (Fig. 1*L*). Areas that yield more than 10 inches of surface runoff make up less than 2 percent of the land area of the Southwest. Intermediate areas, which yield 1 to 10 inches, make up 10 percent. Most watersheds yield less than 1 inch of surface runoff (Fig. 2).

Sediment-producing lands bear almost a reciprocal relation to water-yielding areas. Heaviest sediment loads are produced at the lowest elevations where plant cover

FIG. 1.—Examples of water- and sediment-producing lands in the Southwest. (*Left*) Greatest potential and actual runoff exists in the higher mountains where most of precipitation is received as snow. (*Right*) *Where the plant* cover is poor because of low precipitation or improper land use, sediment production from gully and sheet erosion is high.

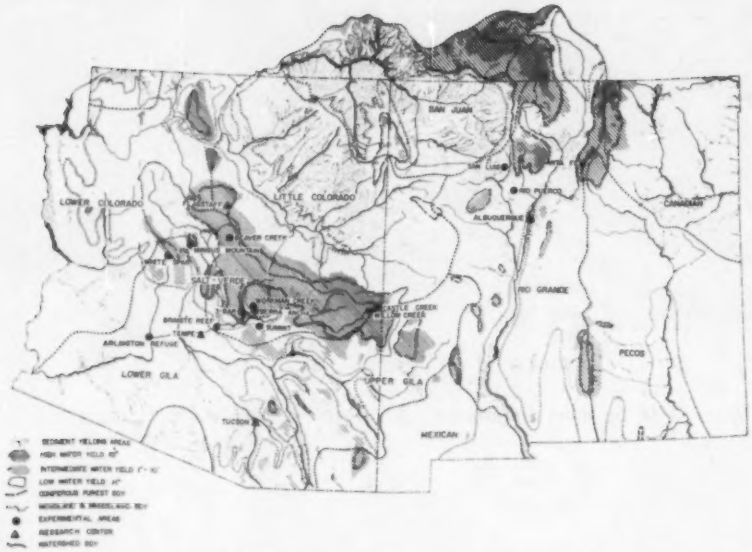

FIG. 2.—Location of water- and sediment-producing areas in the Southwest in relation to broad types of vegetation, major drainages, and experimental areas.

is scarce as a result of low precipitation and improper land use (Fig. 1*R*). Sediment production tends, with minor exception, to decline as increasing precipitation at the higher elevations produces a better protective plant cover.

Floods in the Southwest are either general and of infrequent occurrence or they are frequent but of local origin. The more general, infrequent floods usually result from warm rain falling on melting snow during the spring. Local flash floods are associated with high intensity thundershowers on shallow, rocky soils, or with insufficient plant cover for retarding overland flow and promoting rapid infiltration.

Research Emphasis

At the higher elevations, watershed management research has emphasized finding ways to manage vegetation and snowpack so as to obtain greater water yields. More knowledge of the relation of kind, form, and arrangement of forest cover to water yield is urgently needed.

At the lower elevations, the major problem of watershed management is to improve soil stabilization and reduce sedimentation. This may necessitate mechanical structures and improvement of vegetation or both. If on-site use of water is increased by developing or improving a usable vegetation, overland flow and attendant soil movement may be decreased, and secondary beneficial watershed products such as grass may be increased.

In the intermediate water yielding zone, research seeks to coordinate watershed management practices with timber, range, and wildlife habitat management (Fig. 3). The most important question to be answered, at least at present, is the effect timber, range, and wildlife habitat management practices have upon water yields and sedimentation.

Water transport is somewhat of a problem in the low and intermediate water-yielding areas. Many channels are sediment or debris laden, or contain dense growth of non-economic but high-water-using plants.

Research Organization

Watershed management research by the Forest Service is controlled and coordinated by the Rocky Mountain Forest and Range Experiment Station, which is headquartered in Fort Collins, Colorado. Research responsibilities are assigned according to vegetational

FIG. 3.—Coordination of watershed management with other land uses is an important problem in the zone of intermediate water yield. (*Left*) Research is now attempting to determine what effect reducing stocking of timber to the desired level has upon water yield and sedimentation. (*Right*) Removal of invading juniper from grasslands is now an accepted range improvement practice in the Southwest. Watershed studies have been designed to test what effect this improvement practice has upon water yield and sedimentation.

types. These are: mixed conifer and aspen forests (worked from Tempe and Albuquerque), mountain grasslands (Tempe and Albuquerque), ponderosa pine (Tempe and Flagstaff), pinyon-juniper (Flagstaff), chaparral (Tempe), desert shrub and grassland (Albuquerque), and phreatophytes (Tempe).

Areas for intensive research are located in each vegetation type. For the mixed conifer and aspen, these are in the Sangre de Cristo Mountains near Santa Fe, New Mexico; in the White Mountains near Alpine, Arizona; and in the Sierra Anchas near Globe, Arizona. For the ponderosa pine type, major studies are located on the Coconino, Apache, and Tonto National Forests. Pinyon-juniper experimental watersheds have been established near Flagstaff, Arizona, on Beaver Creek. For the chaparral type, experiments are conducted near Prescott and Globe, Arizona, in the Mingus, Bradshaw, Mazatzal, and Sierra Ancha Mountains. Phreatophyte research is concentrated along Salt River above Phoenix near Granite Reef Dam and on the Arlington Wildlife Refuge.

Some Research Objectives and Studies

1. In the mixed conifer and aspen forests, research emphasis is directed toward management of snow. At present, this includes studies of accumulation, melt, and evaporation under different conditions of vegetation, topography, climate, and soil. Studies are also being made of soil moisture changes under stands of different plant species by gravimetric and neutron methods of measurement and sampling. Experimental watersheds have been and are being calibrated where different systems for water yield and timber management can be tested.

2. In the ponderosa pine forests, the main research concern at present is to determine the effect of timber management practices upon water yield and sedimentation and the possibility of coordinating water yield practices with timber management. This approach necessitates determining values for interception by canopy and litter, and soil moisture and surface flow relations for different character and structure of ponderosa pine forests. Experimental watersheds are being calibrated where timber management practices, such as thinning, pulpwood harvest, improvement cuttings, and prescribed burning can be evaluated in terms of their effect upon water yield and sedimentation.

3. In the pinyon-juniper woodland, grazing and game values are believed to be most important. A common range improvement practice is to convert grasslands from an invading overstory of junipers to a full cover of perennial grasses. To evaluate the effect of this conversion on watershed values requires a basic understanding of the disposition of rainfall on converted and unconverted lands. Research studies are concerned with measuring interception, surface runoff, water use, and soil moisture relations. Experimental watersheds will soon be calibrated to determine the effect of range improvement practices on water yield and sedimentation.

4. In the chaparral type there are two major problems. Shrub live oak is the main component of the type, and, except for its function in soil stability, it is believed to contribute little to the production of game or livestock. If this abundant but low value species could be replaced by a species with higher grazing value and lower water requirements, water yields and other economic products of the type might be enhanced considerably. Secondly, the chaparral type is periodically swept by wildfires. For several years following a wildfire, soils are highly instable.

Several studies in the chaparral type deal with evaluating water and forage effects when a dominantly shrub cover is converted to perennial grass. Also, individual species of shrubs are being compared with regard to their water use and their value for livestock and game. Soil stabilization resulting from seeding to perennial grasses after wildfires is being studied on plots and experimental watersheds. Other watersheds are being calibrated to determine later the effect that chemical treatment of shrubs has upon water and sediment production. Work on herbicides is being conducted cooperatively with the Agricultural Research Service to find the best kind, formulation, volume, and application methods for reducing or eliminating undesirable shrubby species. Prescribed burning for reducing or eliminating undesirable cover is also under investigation.

5. Watershed research work in the desert-shrub and desert-grassland is being conducted, in cooperation with the Bureau of Land Management and Geological Survey, on the Rio Puerco Drainage in New Mexico. In this drainage, lands are eroding badly, contributing heavy silt loads to tributaries, and grazing values are far below their potential. The main problems are reduction of erosion and re-establishment of a plant cover valuable for grazing. The effect of ripping, listing, and revegetation upon overland flow and sedimentation are being evaluated.

6. Phreatophyte research is concerned with plants that grow on flood plains or along streams where their roots have access to a permanent water supply during the growing season. One research approach is to determine the evapotranspiration losses of different native species and possible replacement species to discover the plants using the least water. Secondly, ecological information is being accumulated to provide a basis for designing a program for removal of phreatophytes and their replacement by species using less water or having greater economic value. Investigations include determination of germination requirements, establishment factors, growth rate, and other ecological phenomena.

Conclusion

The Southwest (Arizona and New Mexico) is characterized in general by low water yields and high rates of sedimentation. Information for managing watersheds is

urgently needed because an increasing population is demanding a greater supply of water and other products, such as timber, livestock, game, and recreation from the watersheds. Research by the Forest Service is emphasizing water yields at the higher elevations, coordinating watershed with timber and range management in the intermediate zones, and reducing flood flows and sedimentation at the lower elevations. Solution of the many watershed management problems is a searching challenge to the ingenuity and imagination of researchers. Efforts should be fully repaid by the development of watershed management practices that will permit more intensive yet better use of watersheds by an expanding population.

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Alpine Snow Research

M. Martinelli, Jr.

IN THE Central Rocky Mountains, between two-thirds and three-fourths of the annual precipitation falls as snow (*1, 2*). Since little of this snow melts during the winter, streamflow is governed largely by the spring melt. Streams in this area carry as much as 70 percent of their annual flow during the three-month period April-June. The demand for water, on the other hand, reaches its peak later in the summer when agricultural and municipal requirements are highest. A complex system of reservoirs and feeder canals has been developed to store surplus water during the spring freshets and release it when demands increase. Although this storage system has proved satisfactory, there is still need for management techniques that can increase summer streamflow by altering the hydrograph or increase total annual water yield by reducing evapotranspiration losses.

Management of the alpine snowpack is one way to increase summer streamflow. Because water yield in the Rocky Mountain area is so closely related to snowmelt, it is logical to concentrate research efforts to increase summer streamflow in those areas where snow is present during the summer months (Fig. 1).

The Research Program

The alpine snow research program at the Rocky Mountain Forest and Range Experiment Station has two major objectives. The first is to learn how much water alpine snowfields contribute to streamflow. The second is to develop management techniques that will increase the water yield from these snowfields during the summer.

In order to achieve the first objective, a survey was made of ablation (disappearance of snow due to melt and evaporation) and density at a group of alpine snowfields under summer conditions. This survey was followed by a study of the rate of evaporation and condensation at a summer snow surface.

There appear to be two approaches to the second objective. One is to regulate the rate of melt by adding material to the snow surface. The other is to increase the depth and extent of alpine snowfields by the use of artificial barriers.

Information from Completed Studies

A survey of selected alpine snowfields in central Colorado during the summers of 1955-1958 con-

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firmed our belief that such fields are important contributors to summer streamflow (*5*). This work showed that vertical ablation averaged 1.9 feet of snow per week during July and August. Specific gravity of the snow varied from 0.60 to 0.75. This means that about 1¼ feet of water were released per unit area of snow. Of course, not all of this water would be available for streamflow if evaporation were an important factor in ablation. However, net evaporation from snow surfaces during the summer has generally been found to be small (*3, 4, 7*).

Vapor transfer studies carried out in the alpine portion of Colorado during the summers of 1957 and 1958 showed a net gain of moisture on the snow surface from condensation during a nine-day period of humid weather and a net loss of moisture from the snow due to evaporation during a period of dry, windy weather. Net vapor transfer averaged only 2 to 3 percent of the daily melt. Never during the two test periods did it exceed 4.5 percent of daily melt (*6*). Hence, if we assume a linear decrease in snowfield area with time, 11½ acre-feet of water would be released to the streams during July and August, for each acre of snow present on August 1 (Fig. 2).

The rate of melt in alpine snowfields can be regulated, to a limited degree at least, by the application of materials to the snow surface. Theoretically, the melt rate could be increased by as much as 35 to 40 percent if the albedo (reflectivity) of the snow could be reduced from 0.5 to 0.1. Preliminary tests during the summer of 1956 showed that a thin layer of dark material increased melt about 9 percent. A two-inch layer of sawdust decreased melt by about 50 percent. These results would doubtless be noticeably improved by better field techniques.

Work in Progress

Current efforts in the alpine snow research program are fourfold: (1) Winter observations and measurements of snow accumulation in the alpine to gain a better

FIG. 1.—In the rolling terrain above timberline, winter winds build deep snow drifts that persist far into the summer. Melt water from these snowfields appears to be an important factor in maintaining summer streamflow in the Rocky Mountain Region. Current research is exploring the possibility of increasing summer streamflow by enlarging the late-lying snowfields and by deepening those that normally disappear early in the summer.

FIG. 2.—Alpine snowfields in central Colorado yield about 11½ acre-feet of water during July and August for each acre of snow present on August 1. The above picture was taken on August 24, 1957. At that time, 5½ acres of snow were producing about 326,000 gallons (1 acre-foot) of water per day.

understanding of where and under what weather conditions deep drifts develop, (2) Exploratory studies using standard snow fencing to increase the amount of snow trapped in natural catchments, (3) Basic studies of the spatial distribution of wind-transported snow under field conditions, and (4) Analysis of aerial photographs to determine the amount of snow in a selected portion of the Front Range of Colorado at the beginning and end of the same summer. Most of this work is being done at Loveland Basin, one of the alpine bowls west of Denver. Ski lifts and adequate roads make this area accessible year around.

Accumulation.—Winter observations of snow accumulation in the alpine for the past two years have furnished some quantitative data on local drift patterns. In addition, these observations verified published information on conditions conducive to drifting. It has been observed that snow transport starts in the unprotected spots, with winds above 10 to 12 mph provided the snow surface is not crusted. At some higher speed, perhaps 25 to 35 mph, all snow not in the immediate lee of vegetation or terrain irregularities is subject to wind erosion. Thus, snow drifts that develop in relatively exposed situations with light winds are carried away at higher velocities. Winds can move snow more effectively after surface irregularities are filled by snow and the terrain is smooth. Maximum accumulation of snow takes place in the natural catchment areas when strong winds follow or accompany moderate or heavy snowstorms. These general observations are substantiated by other workers in many parts of the world. In addition, it was noted that under local conditions, a few heavy drift periods accounted for most of the winter accumulation. For example, a single storm in December 1958 was responsible for 20 percent of the winter's accumulation of snow at the Loveland Basin study area. At that site, five major storms in the winter of 1958-1959 contributed 62 percent of the year's accumulation.

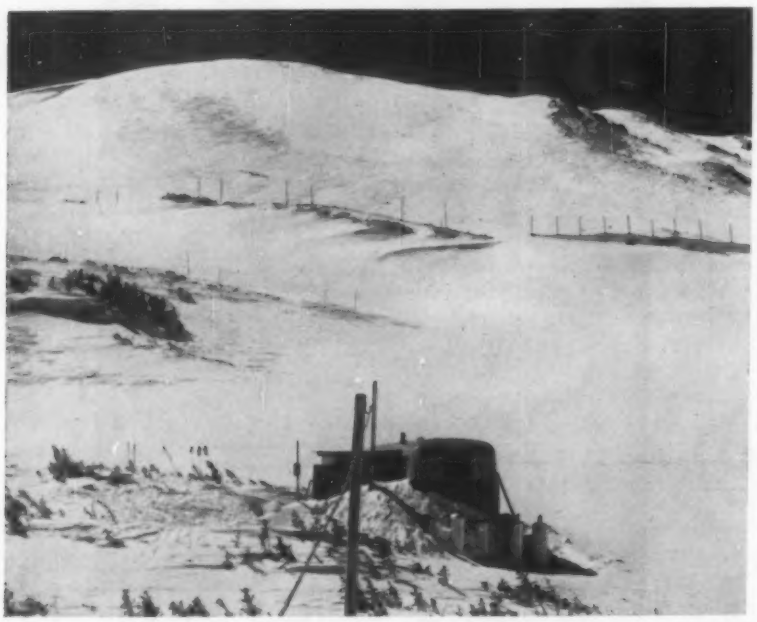

FIG. 3.—The drift behind the fence on the intermediate ridge illustrates how an artificial barrier can be used to increase the efficiency of a natural snow trap. Average snow depth behind fence was 15.5 feet while that in the catchment to the left of the fence was 9.2 feet.

Years vary as to the amount of snow, number of storms, and wind conditions. Nevertheless, for a given alpine area, spring melt will reveal a pattern of late-lying snowfields that is characteristic for that area. True, the snowfields may vary in size, depending on the amount of snow and spring weather conditions, but their location is fixed by the terrain feature behind which they form.

Field observations also indicate that in many alpine areas natural catchments fill early in the accumulation period. After the natural barriers are saturated, subsequent snows are swept down the mountain and deposited at lower altitudes. Melt water from such snow reaches the streams during the spring melt when streams are already full.

Fencing.—Experiments are under way to see if artificial barriers can be used in conjunction with natural terrain features to increase the amount of snow trapped in the natural alpine catchments (Fig. 3). To date only standard, vertical slat and wire snow fencing has been used. Tests during the winter of 1956-1957 showed no appreciable advantage in erecting this type of fence so that it leaned into or away from the prevailing wind nor in overlapping two sections to get greater density. A single thickness of fence on vertical poles was easier to put up and in these tests appeared to trap as much snow as the more elaborate fences. Later studies at a more exposed site revealed structural weakness in the simple vertical fence. Constant flexure of the wire around the poles caused fatigue and eventual failure. At the same site unguyed, number 10 transmission poles (16 feet tall, 10-12 inches butt diameter) broke near the ground line when supporting a standard fence 8 feet tall. Construction methods are still being studied. One type of construction using a cable suspension to reduce wear on the wire in the fence may be ready for testing in the near future.

Wind transport.—Preliminary studies to date have demonstrated

the need for more basic information on how snow is transported by the wind. Field investigations of the amount and spatial distribution of airborne snow during periods of snow drift were started in the winter of 1959-1960. They will involve the vertical distribution of airborne snow at several places in the alpine areas. For example, the vertical profile of drifting snow passing the primary ridge will be compared to that at secondary ridges in the basin to the leeward. Correlations will be made between wind speed, snow surface conditions, synoptic weather conditions, and the amount of drifting snow. In addition, instrumentation will be designed and tested to measure the time of occurrence and amount of precipitation above the zone of wind transport. This information will be used to improve the design and location of artificial barriers.

Aerial mapping.—A selected portion of the alpine area of the Colorado Front Range was photographed from the air twice during the summer of 1956. One set of photographs was taken at the end of June, the other in mid-September. These pictures are being analyzed to determine the difference in snow cover during the summer. Water yield by drainages will be computed by using density, ablation, and evaporation data from field studies in the area. A comparison of computed water yields and actual streamflow records will give an indication of the importance of the late-lying snowfields in maintaining summer streamflow for one of the important water-producing regions of Colorado. These photographs will also offer a good chance to study the terrain configurations conducive to the formation of snowfields.

Work Planned for the Future

In addition to snow fencing, two other methods for increasing the amount of snow retained in alpine areas merit attention. These are induced avalanching and modification of the land surface to increase the deposition of snow. Frequent avalanching would cause snow to be piled into a small area at the toe of the slope. The rate of melt in such deep snow accumulations would be slower than in the relatively shallow snow on the steep slopes. This would be especially true if the accumulation were on a shaded north or northeast exposure. Depressions dug at the toe of the slopes to receive the snow would also help prolong melt by concentrating the snow in deep piles. The usual method of artificially releasing avalanches is to use high explosives; however, numerous other methods are also known. They range from the track of a skier across the fracture zone to the sonic boom of passing aircraft.

The enlargement and reshaping of natural snow storage areas by dirt moving equipment offers a direct and fairly simple way to trap snow. There are many alpine areas in Colorado where it is possible to deepen existing snow catchments by removing dirt and rock from the floor of the catchment and piling it on the windward edge. However, before pursuing this approach it would be well to have a better idea of optimum shape and alignment for such catchments either from more extensive field observations or from wind tunnel tests.

Anticipated Problems

When the above techniques for managing alpine snowfields are perfected and ready for field use, certain problems can be anticipated. Less forage will be available in areas where relatively shallow snowfields are deepened enough to last all summer. Avalanche hazard may be increased in certain limited areas where more snow is stored in steep terrain. Erosion problems will be created by the movement of material and equipment across alpine grasslands if routes are not carefully planned. And finally, alpine ranges could be wrecked by bulldozers used to build snow traps unless the work is confined to natural snow catchments where vegetation is sparse. However, none of these problems should offer serious difficulties once they have been identified.

Conclusions

The storage of water in the form of high-altitude snowfields offers several unique advantages. In the first place, water is released to the streams during the period of heavy use. The prolonged melt period means a reduction in peak streamflow and a decided improvement in water quality. In addition, the water is stored at an altitude and in a form least subject to evaporation losses. Such high-altitude storage also means the water is available to all users in the watershed—not just those below the reservoirs.

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Research in Management of Snowpack Watersheds for Water Yield Control

Henry W. Anderson

	million acres	Av. ann. water yield million acre ft.	percent
Woodland-brush-grass	18	9	12
Forest belt below snow zone	12	23	32
Forest belt in snow-pack zone	9	27	38
Alpine snow zone	3	9	13
Total	42	68	95

FIG. 1.—Major water-yield areas of California showing the location of the study areas for the cooperative snow management research program (*8*).

THE SNOWPACK zone covers about 12 percent of California and is the state's principal source of water supply (Fig. 1); the zone lies above 3,500 feet in the north and above 5,000 feet in the south (*8*). How can the forests be harvested and the vast fields of brushland and open land in this zone be managed to improve water yield? To develop some answers and test them, the Forest Service in cooperation with the State of Calfornia Department of Water Resources has 18 studies under way in the headwaters of five major California rivers.

Timber harvests are moving upward in the high-elevation true fir and mixed conifer forests. Watershed managers must learn how to cut forests and manage other land in this belt in ways that will exert control over water releases—to guard against deterioration of water supplies originating there, and to improve streamflow. We must be able to predict the consequences of various methods of managing watershed land in the snow zone in terms of increased yield, delayed yield, water quality, floods, and sedimentation.

Study areas.—California's snow management research is under way in six study areas (Fig. 1):

1. Berkeley—project headquarters: inventories and analysis of water yield, forest conditions, and sedimentation in the snow zone.

2. Central Sierra Snow Laboratory (Yuba River)—main snow management research field station: studies of basic meteorology, snow

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physics, and forest hydrology; special study of the effects of commercial logging and freeway construction on streamflow and sedimentation.

3. Onion Creek Experimental Forest (American River)—plot tests of the effects of commercial logging and of brush conversion on snow and moisture losses; calibration of five experimental watersheds for evaluation of alternative management methods.

4. Teakettle Experimental Forest (King's River)—calibration of 5 experimental watersheds to test the effect of forest cutting and grazing practices on streamflow and sedimentation.

5. Swain Mountain Experimental Forest (Feather River)—plot studies of the effects of cutting forests in strips and blocks, slash disposal, and game management on snow accumulation and soil moisture losses.

6. Sagehen Creek (Truckee River)—plot and watershed tests to relate the effects of brush clearing and reforestation to water yield, sedimentation, and fish habitat.

Inventories guide research.—An inventory of the forest and land conditions and topography of the western Sierra Nevada above 5,000 feet elevation has been completed. The kinds of forests and their densities, sizes of openings and their ground conditions (brush, grass-herb, bare ground, or rock outcrop), have been determined from analyses of aerial photographs. The inventory has shown that 58 percent of the Sierra snow zone is non-forested (*10*).

	Percent of area
Forested (canopy cover greater than 15%)	42
Non-forested	
Bare ground and rock	29
Brush covered	17
Grass-herb	7
Other, tallus, crops, lakes, etc.	5
	100

A second inventory utilizing streamflow records will fill in details of the water yield picture; where and when water is yielded from the different slopes and aspects of the snow zone. A third is characterizing the soil erodibility of the major soil-geologic types.

TABLE 1.—SUMMARY OF SNOW ACCUMULATION AND MELT, CENTRAL SIERRA, 1958

Condition	Snow water—inches		
	April 22	*June 1*	*Melt*
In forest openings	63.2	26.8	36.4
In forest adjacent to openings	56.0	25.1	30.9
In dense forest (80-100)	48.1	19.0	29.1
In moderate forests (50-80%)	50.3	25.0	25.3
In open forests (20-50%)	57.7	25.0	32.7

Basic studies of snow accumulation and melt.—Eighty-three snow courses were selected at elevations ranging from 6,000 to 7,800 feet to study snow accumulation and melt in all combinations of slope steepness, slope direction, forest density, opening size, and ground cover condition. Snow has been measured at monthly intervals throughout the winters of 1957-1958 and 1958-1959.

First results—analyses have been made of the 1958 snowpack in various forest conditions at the time of maximum snow accumulation, on April 22, 1958 and again on June 1, 1958 (*5, 7*). Maximum accumulation of snow and maximum melt (average for all slopes) were in forest openings (Table 1).

Basic studies of heat and radiation.—It takes heat to melt snow. Preliminary studies have shown that snow zone forest stands receive widely different amounts of heat (*4*); management presumably will differ in these stands. Other studies have shown that forest effects on snow are best evaluated by relating them to the solar radiation received at the snow surface, the back radiation from the trees, and the interchange of energy between the clouds, the sky, and the forest (*3*).

Basic wind measurements.—A basic study of wind direction and velocity during snow storms showed that 83 percent of the snow fell with southerly winds (*9*). The study also showed wind velocity varied widely from storm to storm, the medians ranging from 2 to 14 miles per hour. Wind velocities in non-storm periods were less, and south winds were less dominant. The results of this study help explain snow accumulation patterns in forest openings and adjacent stands (*5*).

Winter and summer water loss studies.—Winter water losses by interception and evaporation are being measured. Interception losses of snow by forest canopies were about 8 percent (*12*). Snow evaporation is least under forest canopies and in small forest openings

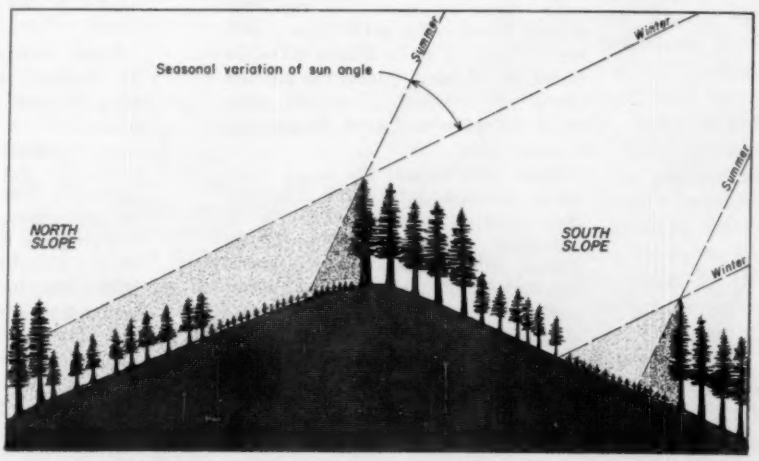

FIG. 2.—"Ideal Forest," a wall-and-step forest, resulting from strip cutting, with the direction of strips normal to the direction of maximum solar radiation, wider strips on north than on south slopes.

(*2, 12*) and greatest in large openings and exposed ridges. Evaporation losses in 1958 under forest stands were 0.9 inches, and 1.7 inches in small openings (*12*). Losses in large openings and on exposed ridges were one and one-half and three times that of small forest openings (*11*).

Summer water losses are measured by a radioactive soil-moisture probe at 37 sites (*12*). In 1958, losses from old-growth red fir forest were 7.7 inches, from young forest 7.4 inches, from wild sunflower 6.1 inches, and from bare ground 3.9 inches.

Application of findings.—Preliminary results suggest how a forest might be cut to produce the "ideal forest" for snow accumulation and delayed snow melt (Fig. 2). On north and south slopes and on level areas, cutting successive strips of forest to the southward, would produce a wall-and-step forest, resulting in maximum shade from trees to the south and minimum radiation from trees to the north of the cut strip (*1*). North slopes are less exposed to the sun, and strips can be wider (*3*). On west slopes we can cut an L-shaped opening, one arm of the L extending to the north, the other uphill to the east. On east slopes, the L is reversed, one arm extending uphill to the west. Such L-shaped openings will be cooled by radiation; cold air from the uphill arm will drain down into and be trapped in the other arm (*5*). These hypotheses will be refined and tested in subsequent studies.

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Western Snow Conference

The three-day session of the 28th annual Western Snow Conference will begin April 12 at La Fonda Hotel in Santa Fe, N. Mex. About 150 participants are expected. They will come from the western United States and Canada.

Topics will include the use of snow water forecast information, streamflow computing, new techniques in snowpack measurement, avalanche control, reducing reservoir evaporation and the possible management of snowpack.

Specialists from this nation in the various problems involved in snow surveying will be joined for the discussion by at least two from other nations.

Snow surveys have been made in the western mountainous areas for about 50 years. In 1935, Congress first recognized the importance of the surveys and appropriated funds for the work. The former Bureau of Agricultural Engineering first carried out the assignment, but responsibility for directing the work was placed on the U. S. Soil Conservation Service in 1939. The snow survey effort each winter and spring is a vast cooperative activity with many agencies and institutions involved.

Watershed Management Research in the Northeast

Howard W. Lull

THE NORTHEAST has—and rightly so—an urgent concern for its water resource. It has a big stake in watershed management research.

In total area this region is small: it comprises only 7 percent of the area of the United States. Yet it contains 29 percent of the nation's total population. Its population density is more than four times the national average.

In this 12-state region (it includes the New England States and New York, Pennsylvania, New Jersey, Delaware, Maryland, and West Virginia), most of its 44 million people are concentrated along the coast and in inland cities situated along major rivers.

Flying over this region, one sees great areas of factories and housetops interlaced with asphalt streets and concrete super-highways. In these homes and factories the water resource is taken for granted. Its source is the faucet. Rainfall is a nuisance that slows traffic and spatters commuters.

But back of these metropolitan areas lie, in great part, the forest resource. And here is another unusual statistic: though the Northeastern region has only 7 percent of the land area, it has 12 percent of the nation's total forest land. This forest land is the source of much of the streamflow that supplies the water needs for the millions of homes and the gigantic, massed industrial complexes of the region.

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The high population of the region is a testament to water supplies that have been adequate—30 to 60 inches of rainfall evenly distributed throughout the year—in the past. But now, steadily increasing population is imposing a burden on these supplies (particularly on low summer flows); and the spread of suburbs and industry is creating areas that produce higher peak flows and are subject to their destructive forces. Here then are the paradoxical problems—water shortage and floods—that are common to densely populated areas where the land has been used hard.

And the Northeastern forests have been used hard. Before the time of the Pilgrim Fathers, Indians had kept large areas burned over. The settlers clearcut much of the original forest. The land was farmed hard until railroads, bringing low-priced farm products from the West, made many Northeastern farms unprofitable. Then large areas in southern New England and elsewhere reverted to low-value hardwoods; and they too, have been cut. Today about one-third of the region's forest area is in young growth.

This hard use has undoubtedly affected streamflow; how much, we do not know. Equally unknown are the effects on streamflow of present forest cover and of changes in this cover. The fact that these forest lands are the principal water sources for downstream metropolitan areas justifies intensive research to determine the influence of these lands on water supplies and how they can be managed to improve water yield without loss of water quality.

Research Begins

Forest watershed management research is a latecomer to the Northeast. Intensive watershed studies were started in the West at San Dimas (California) and in the Southeast at Coweeta (North Carolina) in the early 1930's, but in the Northeast there was no organized effort until 1948, when field units of the Northeastern Forest Experiment Station were set up at Elkins, West Virginia, and Bethlehem, Pennsylvania, to conduct watershed research.

Before 1948 the little research that was done in the region was mostly in the field of forest influences. It included studies conducted by the U. S. Forest Service, seeking information for flood control surveys, and studies by graduate students and faculty members of the Yale and Harvard Forestry Schools. From 1934 to 1947 sixteen papers on forest influences were issued by the Allegheny and Northeastern Forest Experiment Stations. Six of the Yale University School of Forestry Bulletins and three Harvard Forest Bulletins dealt with forest influences on light, temperature, soil moisture, and soil development; in addition, a number of shorter papers by faculty members and students were published. Other early studies include those on infiltration and interception by the late Robert E. Horton, eminent consulting hydraulic engineer of Voorheesville, New York.

Two Geological Survey studies deserve mention. One is a 1912 comparison of snow melt and streamflow from burned and un-

burned forest watersheds in the White Mountains. The other is a study begun in New York State in 1932, at the suggestion of Franklin D. Roosevelt, to determine the effect of conifer plantings on streamflow.

After 1948, forest watershed management research progressed more rapidly. Graduate-level work in watershed research was started at the forestry schools of The Pennsylvania State University, the State University of New York at Syracuse, and Yale University. In 1955 the Northeastern Forest Experiment Station's Hubbard Brook Experimental Forest in the White Mountains of New Hampshire was set aside for watershed management research. In 1957-1958 the Station started cooperative watershed studies with The Pennsylvania State University, and with the cities of Baltimore, Maryland, and Newark, New Jersey.

Current Research

The watershed-research program of the Northeastern Station has been described in recent annual reports and in 64 papers published during the past 10 years. The following information on research conducted by forestry schools and other agencies was obtained largely by correspondence. In all, the studies summarized below are conducted in 7 of the 12 Northeastern States.

New Hampshire. — Streamflow from four experimental watersheds is being gaged at the Hubbard Brook Experimental Forest. Studies of rainfall interception, snow accumulation and melt, soil frost-humus-snow depth relationships, and soil moisture regimens under forest cover are under way. In the next few years considerable effort will go into road and weir construction to complete the planned network of 12 to 15 gaging stations. When this construction work is completed, Hubbard Brook will be the largest of the Northeastern Station's watershed centers.

Connecticut.—The School of Forestry of Yale University has conducted a graduate course in *Problems of Watershed Management* since 1957 and provides collateral courses in forest soils and forest meteorology.

New York.—The longest-lived watershed study in the Northeast has been conducted since 1932 in central New York by the U. S. Geological Survey and the New York State Conservation Department. Its purpose is to determine the effect of reforestation on streamflows. A progress report was issued in 1949.

At the College of Forestry of the State University of New York, watershed studies on the graduate level have been conducted since 1955. Courses in forest influences, forest soils, and problems in watershed management are given, and field plot studies are under way at the Anna and Archer Huntington Forest in the Adirondacks.

At the Northeastern Station's Paul Smiths Research Center in the Adirondacks, snow accumulation and melt plus frost incidence and depth are being studied in relation to forest type and condition.

New Jersey.—The City of Newark, in cooperation with the Northeastern Forest Experiment Station, initiated a watershed management research program in 1958 on its 36,000-acre Pequannock watershed. Three weirs have been built and a climatic station is in operation.

The cooperative study at Newark and cooperative studies in Maryland and Pennsylvania are administered by the Northeastern Forest Experiment Station from its New Lisbon Research Center on the Lebanon Experimental Forest, about 20 miles east of Philadelphia. Studies of soil-moisture use by forest vegetation are conducted at this Forest, and studies of the effects of waste-water recharge on forest growth and soils have been carried out at Seabrook, New Jersey, with cooperation of the U. S. Geological Survey.

The U. S. Geological Survey, in cooperation with Rutgers University and the New Jersey Division of Water Policy and Supply, is also conducting a watershed study on the Lebanon Forest to determine the effect of forest-management practices on interception, infiltration capacity, evapotranspiration, and yield of water-bearing sands in the area of the New Jersey Pine Barrens. Two watersheds are being studied; one of which is to be left in its natural condition while prescribed burning is to be done on the other. This work began in 1952.

Pennsylvania.—The School of Forestry of The Pennsylvania State University has had an active research program since 1942. Their investigations have included studies of infiltration in relation to plant succession, the hydrologic characteristics of strip-mine banks, and soil freezing. Three studies are now under way on the disposition of precipitation in red pine plantations and mixed-oak hardwood forests. Interception, infiltration, percolation, and soil-moisture records are being obtained.

In cooperation with the Pennsylvania Department of Forests and Waters and the Northeastern Forest Experiment Station, three stream-gaging stations were built in 1957-1958 on university and state forest land, and two climatic stations were established. The three experimental watersheds range in size from 200 to 300 acres. Streamflow and associated climatic data are analyzed by graduate students. Courses in watershed management are available for both undergraduate and graduate students.

At the Delaware-Lehigh Experimental Forest on the Pocono Plateau, the Northeastern Forest Experiment Station and the Pennsylvania Department of Forests and Waters have worked together collecting 10 years of streamflow and climatic records on a 1,530-acre scrub-oak watershed. The watershed has been calibrated and will be planted to conifers. Stream-gaging will be resumed in the future to determine the effects of the planting on water yield. Similar records have been taken on a 560-acre northern hardwood

watershed at the Pocono Experimental Forest, and the effect on streamflow of cutting this area will be determined in a continuing study.

Maryland.—The Bureau of Water Supply of Baltimore is gaging streamflow from three small watersheds located on the 17,300 acres of city-owned forest land surrounding the Bureau's reservoirs. The purpose of this study, which is in cooperation with the Maryland Department of Forests and Parks and the Northeastern Forest Experiment Station, is to compare streamflow from conifer-plantation watersheds and hardwood forests, and to determine the effect of forest cultural methods on streamflow.

West Virginia.—The most advanced research program in the Northeast is under way at the Northeastern Station's Fernow Experimental Forest near Parsons. Nine experimental watersheds, ranging in area from 29 to 96 acres, are being gauged. Seven are forested and two are in abandoned pastures which are reverting to forest. Five watersheds were calibrated using 6 years of daily streamflow and precipitation records. Four of these watersheds were subjected to different types of forest cutting in 1957-1958 (one watershed was left uncut as a control). First- and second-year results show marked effects of heavier cuttings on summer water yield and on water quality.

Future Patterns

In all, 30 experimental watersheds in the Northeast are being studied to determine how forest cover, and changes in cover, affect streamflow—water yield, distribution in time, and water quality.

Sustained interest in this subject may be expected with continuing and growing realization that the water resource has limits bounded by seasonal availability and storage availability, and with increasing knowledge of the effect of forest management on water yield.

There are in the Northeast more than 300 communities that have forest properties either protecting the banks of their reservoirs or protecting their water-supply areas. About one million acres of forest land are involved. This municipal-forest area will probably form the nucleus of land for intensive watershed management in the future.

Gaging watersheds alone will not provide the ultimate answers for management. More and more dependence will be placed on studies of fundamental hydrologic relationships that will serve to explain the differences resulting from watershed treatments. Only through these studies will it be possible for watershed managers to apply research results with confidence.

SOUTHEASTERN SECTION Officers for 1960. *Left to right*: K. R. Swinford, professor in School of Forestry, University of Florida, secretary-treasurer; J. W. Owens, Jr., Gulf State Paper Corp., Tuscaloosa, Ala., chairman-elect; Donald Stevenson, Buckeye Cellulose Corp., Foley, Fla., chairman; Leon Hargreaves, Georgia Forestry Com., Macon, outgoing chairman; L. C. Walker, assistant professor, Forestry School, University of Georgia, outgoing secretary-treasurer.

Watershed Management Research in the Lake States, Intermountain, and Pacific Northwest Regions

E. G. Dunford

FROM Lake Huron to Puget Sound lies an expanse embracing two major mountain systems, wide bands of virgin timberland, and intervening areas of grassy plains. Including the Great Basin of Utah and Nevada, the area supplies water to four major rivers—the Columbia, Missouri, Mississippi, and Colorado.

Most watershed management research in forests and ranges of this 10-state area is done by the U. S. Forest Service, but important contributions also come from other sources. Some of the state universities and two forest-industry research organizations are adding to knowledge of watershed management through their investigations of forest soils. The State of Oregon, in cooperation with several federal agencies and one forest-products concern, is making a limited study in the Alsea River basin, a 400-square-mile watershed on the west side of Oregon's Coast Range.

Activities by the Forest Service are centered in three units—the Pacific Northwest, Intermountain, and Lake States Experiment Stations, headquartered respectively at Portland, Oregon; Ogden, Utah; and St. Paul, Minnesota. Eighteen technical people carry on the work at 13 separate locations.

Centers of Research

Watershed research at the Intermountain Forest and Range Experiment Station started in 1912. The famous A-B watershed experiment begun that year in the head of Ephraim Canyon, Utah, is America's oldest active watershed study. Floods in the early thirties gave impetus to the Davis County watershed studies in the Wasatch Front and after World War II, research extended to southern Idaho where granitic soils are susceptible to erosion from logging and grazing. Later, a modest program centered at Missoula, Montana, was launched on problems of erosion from logging and road building and methods for improving water yields. Since 1957, a fifth unit at Reno, Nevada, has studied flood problems and sediment movement originating on the east side of the Sierra Nevada.

The Pacific Northwest Forest and Range Experiment Station did no watershed management research until 1955; by 1959 small units operated at four locations in Oregon and at one in Washington. Three in Oregon are on the west side of the Cascade Range, where erosion from logging and road building in old-growth Douglas-fir lands is a critical problem. Studies are concentrated in Bull Run watershed, which supplies Portland's water; at H. J. Andrews Experimental Forest, 50 miles east of Eugene; and in the southwestern part of the state, near Roseburg. East of the Cascades, where objectives are improved regulation of water flows and control of erosion from grazing, programs are located in Oregon's Blue Mountains and on the eastern flanks of the Cascade Range in Washington.

Watershed research in the Lake States began in the early thirties but was interrupted by World War II. Work was reactivated in 1956 and is now carried out at three of the six research centers operated by the Lake States Forest Experiment Station. At Grand Rapids, Minnesota, chief interests are hydrology of bog lands and relation of aspen and brush cover to snow behavior, humus development, and soil freezing. Farther south, at La Crosse, Wisconsin, work is aimed at erosion and flood problems of the Driftless Area, a 10,000-square-mile expanse that escaped levelling action by the continental ice sheet. At East Lansing, Michigan, behavior of groundwater and effect of forest management practices on water regimes are under study.

Watershed Research Studies

At these far-flung outposts, research technicians worked on 50 studies during 1959. Included are investigations of hydrologic and erosional processes and methods to prevent erosion, to rebuild damaged areas, and to improve regulation of streamflow.

Hydrologic and erosional processes. — Twelve of these studies delve into physical laws that govern elements of the water cycle and detachment and transport of soil particles by erosion.

At experimental areas in central and northern Utah, southern Idaho, and western Nevada, investigators study amounts, distribution, and intensity of precipitation to learn what storm types cause surface runoff, erosion, and flooding. In Michigan, Minnesota, and Oregon,

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others are learning how much snow and rain is intercepted by tree crowns.

Most of these workers also give attention to behavior of snow and frost. In Oregon's Blue Mountains, in the northern Idaho white pine region, in the subalpine herbaceous rangelands of central Utah, and in young Jeffrey pine stands near Reno, Nevada, they are searching out physical factors that affect accumulation, water content, and melting rates of snow packs. Types of soil frost have been identified and depths of freezing measured to relate these factors with vegetative cover in northern Minnesota. Tests also show rates at which water can enter frozen soil.

Several studies are designed to give information about use of soil moisture by vegetative cover during the growing season. Two are in old-growth Douglas-fir stands in the Cascades, one in dense lodgepole stands in the Blue Mountains, one in aspen-mountain brush types of northern Utah, another in the Driftless Area of Wisconsin, and still another in the Lower Peninsula of Michigan.

Some of the basic causes of erosion are evident from plots measured for the past 22 years in the Davis County Experimental Watersheds, Utah. In a related study, sediment samples collected during the past 11 years provide a way to determine if particle sizes of the eroded materials are related to amount, duration, and intensity of summer storms.

Protection of watersheds.—Work is also progressing in an effort to learn the practical requirements for minimizing erosion and preventing general deterioration of watersheds. Of 19 studies in this category, all but 4 are located in virgin timber stands west of the Rocky Mountains, where the spread of logging and road networks threatens optimum functioning of watersheds.

The first objective of several studies is to survey present conditions on problem areas. On the east slopes of the Sierra Nevada near Reno, investigators are learning how flood hazards are influenced by soil type, direction and gradient of slope, and condition of vegetative cover. In another study, humus types of the northern Lake States are being identified and their depths measured to give clues regarding the hydrologic condition of forest lands.

Effects of logging on erosion can be evaluated by several methods. Experimental watersheds are providing detailed information on the effect of logging roads on precipitous slopes in an old-growth Douglas-fir forest. In another study, plots on tractor skid trails are showing how surface runoff and erosion are influenced by effect of gradient, length of slope, amount and intensity of rainfall, and type and stoniness of soil.

Another approach is to examine the effects of a variety of logging methods and logging machinery by controlled experiments. A paired watershed experiment will begin soon at H. J. Andrews Experimental Forest to compare one of the recently developed skyline methods with standard high-lead logging in terms of erosion, stream sedimentation, road mileage, and logging costs. A controlled logging experiment in Idaho's Boise River basin is demonstrating the value of planning and careful location of roads in loose granitic soil.

Because roads will continue to be a requirement of good land management, watershed research workers in the northern Rocky Mountains are devising guides for better location and construction of new roads and for postlogging treatment of old roads. Data from 600 road sites indicate what factors influence the eroding power of water and movement of sediment, and other experiments show how these destructive forces can be curbed.

Studies of grazing practices and their influence on surface runoff and erosion are also important activities. One example is a current series of infiltration tests to determine the effect of four grazing management systems on subalpine rangeland in central Utah. Data show the relation of overland flow and soil loss to storms of typical flood-producing intensity.

Restoring depleted watersheds.—Thirteen studies are concerned with deteriorating watersheds. One over-all objective is to develop and evaluate methods of controlling excessive runoff and erosion resulting from mismanagement on rangelands, roads, burned areas, and logged lands. A second objective is to find ways of rebuilding depleted soil and restoring stability of disturbed stream channels and gullied areas.

Contour trenching, fertilizing, mulching, reseeding, and protection from grazing are being examined in the Boise River basin, in the headwaters of Manti and Pleasant Creeks in central Utah, in the Davis County watersheds, and in high-altitude forb ranges and lower winter ranges of Montana. Infiltration measurements have shown density of ground cover needed to control surface runoff and erosion. Accompanying analyses demonstrate the effects of soil compaction, indicating ranges in bulk density values of soil required for adequate water intake. Other studies in Utah show how commercial fertilizers help establish new stands of grass where competition from old plants has been reduced. Disking, contour trenching, and reseeding have reduced overland flow and erosion on Watershed B and similar areas, some of which are now considered capable of supporting controlled grazing. With exclusion of grazing as the sole rehabilitation treatment, Watershed A still contributes surface runoff.

Methods are also being developed to repair disturbance caused by road construction and stream channel erosion. Sample plots on seeded roadbeds indicate need for fertilization but discount the effectiveness of mechanical preparation in establishment of grass cover. Surveys of northern Michigan channels demonstrate that dams and deflectors in streams plus riprap, sod cover, tree plantings, and gully control on the banks are effective in controlling stream channel erosion.

Improving water yields.—The idea that water flows can be altered by cover management has prompted six studies, most of them just beginning. Pretreatment measurement of streamflow is proceeding in experimental watersheds selected in Utah, Montana, Idaho, Washington, and Oregon. Experimental treatments are some years away.

Planned treatments are designed to increase flow, especially in summer months, without adding to peak flows or increasing erosion. In snow zones of the Blue Mountains, on the east slopes of the Cascades, in the northern Rockies of Montana, and on the Wasatch Plateau, objectives are to determine if treatments affecting snow accumulation and melting will alter streamflow. Experiments are also being readied in the rainfall zone at H. J. Andrews Experimental Forest and in Bull Run watershed, to evaluate the effect of cutting old-growth Douglas-fir on yield and timing of streamflow. Similar objectives have prompted studies of cutting practices in bog and swamp forests of the northern Lake States.

Artificial devices for increasing snow accumulation show some promise. On the Wasatch Plateau, drifting was induced by snow fences, indicating a possible method of increasing snow available for spring melt in local areas.

The Future

In the past five years, the small corps of workers carrying on watershed research in the Lake States - Intermountain - Pacific Northwest area has tripled, and a similar rate of growth in the next decade is a minimum requirement to keep pace with research needs. Many in this added force should be specialists because there will be growing emphasis on basic principles. If present plans are followed, at least two regional laboratories will provide centers for fundamental research in soils, erosion, and hydrology. The trend will be toward studies that tell not only *what* happens in watersheds—but also *why*.

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National Watershed Conference

The 7th National Watershed Congress will be held in the Statler-Hilton Hotel, Washington, D. C., April 18-20.

The congress, which was conceived and fostered by more than twenty of the nation's industrial, agricultural, and conservation organizations, is dedicated to improved natural resources management and use on a watershed basis. The yearly meetings afford an over-all review and discussion of watershed programs, problems, and progress.

The congress is not a membership organization, does not propagandize, adopt resolutions, promote projects, or take any action—it is a forum for the discussion of ways and means of expediting and broadening local watershed programs.

The program is designed to benefit everyone interested in watershed development. Prominent speakers will discuss how landowners, community leaders, and local, state and federal officials can work together for sound watershed development. Spokesmen from two states which are leaders in watershed promotion will tell about benefits achieved from shouldering local responsibilities. Key federal administrators will be on hand for comment on specific projects and problems.

All presentations and recorded floor discussions will be published in the printed *Proceedings* of the National Watershed Congress.

The Water Conservation Commemorative Stamp Ceremony is a special event planned only for the Congress. The new 4-cent postage stamp will focus national attention on the urgent need to protect water resources in the forest and fields of the upper watersheds.

Floods Controlled on Davis County Watersheds

George W. Craddock

HIGH on steep mountain slopes in a growing number of places within the Intermountain Region are clustered rows of trenches horizontally crossing areas that had become depleted of plant cover and incised by rills and gullies as a result of land abuse. The purpose of these contour trenches is to prevent floods by restoring control of rainfall runoff on the damaged headwater lands.

The concept of controlling floods at their source by maintaining an adequate vegetal cover on the land is not new to foresters. Their application of this concept was first limited to fire control and regulation of timber cutting and livestock grazing. But these measures failed to regain control of runoff on many seriously damaged watersheds in the West. They also failed, through faulty application or by not being applied until too late, to prevent development of new flood source areas and extension of the flood menace.

Mountain born floods eventually came to Davis County in northern Utah. Their coming to this area is, in part, a sad story of watershed abuse. But the manner in which the flood causes were analyzed, the principles that were followed in designing the control measures, and the high degree of flood control achieved also stand as major contributions to the practice of good watershed management.

Floods Came to Davis County

Pioneers came to Davis County in 1850. They settled on a narrow strip of gently sloping land between the eastern shore of the Great Salt Lake and the western base of the steep Wasatch Mountains. They diverted water from each of the several streams where they issued from the steep canyons to irrigate the valley lands. In time, cattle and sheep were turned out from the farms in increasing numbers to graze on the adjacent mountain slopes during the snow-free summer and fall months.

For almost 75 years the people in Davis County prospered and had no serious water problems. Then in 1923, floods came from five of the canyons in the center of the county (*8*). These canyons again produced floods in 1930. In the same year, four floods issued from a sixth watershed which had not previously flooded.

These floods were nothing like the gradual rise of streamflow to moderately high and readily handled discharges that occurred each spring during the snowmelt season. Instead, they came suddenly in midsummer as churning, barely fluid masses of mud, gravel, and rock. Some of the floods carried boulders weighing up to 100 tons.

The discharges spread out from canyon mouths to engulf homes, block highways, and bury farm lands under raw sediment up to 6 feet in depth. Several persons were killed. Flood damages exceeded $1 million, or nearly one-fifth of the assessed value of all property in that part of the county.

Shocked into action, Davis County citizens asked Governor Dern for assistance. He appointed a Special Flood Commission, which included R. W. Bailey, C. L. Forsling, and R. J. Becraft (*4*). To this trio of geologist, forester, and ecologist must go much of the credit for correctly analyzing the flood causes.

FIG. 1.—Contour trenching used for controlling runoff on damaged watershed slopes in the Intermountain region.

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Flood Causes were Determined

This trio's first efforts were aimed at determining whether the floods were normal events in which man had little or no causative part, as some believed, or were abnormal discharges brought on by misuse or abuse of the watershed lands (*1*).

The volume of the flood deposits and the depth of channel cutting at the canyon mouths were found to be several times greater than all of the deposition and channeling that had occurred in the previous 10,000 to 20,000 years. This geologic evidence clearly showed the floods to be of unprecedented violence in recent geologic time.

It was reasoned that such a catastrophic change in the behavior of the flooding streams could have been caused by a steepening of the channel gradients, by an increase in rainfall, or by a decrease in the capacity of the watershed mantle to take in and store rainfall.

No evidence could be found to support diastrophism or climatic change as possible flood causes. However, contrasting plant cover and soil conditions were found on flood source and nonflood source areas which plainly indicated land abuse as the primary flood cause.

The flood sources were found by following the gutted channels to their origin on the headwater slopes. The sources occurred on scattered areas of less than one to only a few acres in size and, in the aggregate, covered only about 10 percent of the mountain lands. Each bore unmistakable evidence of drastic plant cover depletion and much loss of topsoil. This deterioration was due to long continued overgrazing of livestock and, in some places, by misuse of fire.

There were no signs of storm runoff on areas adjacent to and intermingled with the flood sources, where plant cover had not been so drastically depleted or the soil so thoroughly compacted and eroded. Well vegetated slopes in the middle and lower portions of the watersheds also showed no signs of contributing storm runoff. The more deeply moistened condition of the soil on these areas indicated that virtually all of the rainfall had been absorbed where and as it fell.

The importance of undamaged plant cover in controlling summer rainfall runoff was further demonstrated in Centerville watershed. Many years prior to the coming of floods in Davis County, the people living at the mouth of Centerville Canyon arranged for conservative grazing in the headwaters of that stream to prevent contamination of their water supply. There has been no serious depletion of plant cover in this watershed nor has the area produced any destructive floods.

Control Measures were Developed and Applied

The above evidence strongly indicated that floods could be controlled at their source by restoring the capacity of the watershed mantle to absorb and hold the torrential rainfall. To accomplish this the Forest Service developed a program of four remedial measures. These included the establishment of organized fire control on all of the mountain lands, elimination of livestock grazing on the flood producing watersheds, seeding of perennial grasses on depleted sites, and construction of contour trenches on the gullied flood source areas.

Contour trenches were proposed for several reasons. They were needed to break up the gully system, prevent storm runoff from flowing into the headwater channels and, by trapping water in the trenches, provide favorable soil moisture conditions for regrowth of vegetation. The trenches were to be spaced at about 25-foot intervals and to have a capacity for storing 75 percent of a 2-inch rain on the slopes between the trenches (*2*).

The program posed some difficult operational problems.

One of these was clearing the way for removing the livestock from and installing the contour trenches on the privately owned watershed lands. This was accomplished by locally sponsored Congressional actions which added the mountain lands to the adjacent Wasatch National Forest and provided for the federal purchase of the land from the private owners.

There was also the problem of getting labor and equipment to build an access road to the headwater areas and to do the seeding and contour trenching. This was solved by assignment of a CCC unit to work on the area.

The job got under way in 1933 and was largely completed by 1936. In all, about 1,100 acres were contour-trenched and seeded and an additional 200 acres were only seeded (*3*).

A complete job of contour trenching was done on the flood sources in the Parrish, Barnard, Ford, Steed, and Davis watersheds. These are located between the nonflooding Centerville watershed on the south and the flood producing Farmington Canyon on the north. Contour trenching was not done or only partially done on some of the flood producing subbasins of Farmington Canyon and on Bairs watershed to the north. The mountain lands from Centerville Canyon to Bairs Canyon subsequently were designated as the Davis County Experimental Watershed. (*7*).

Control Measures Tested

Plant cover thickened quickly on the intensively treated watersheds. Adequate densities of plant and litter for controlling storm runoff (*6*) were soon attained on all but the most severely eroded sites, and even on them the trenches trapped the runoff. With this recovery of vegetation also came control of streamflow.

Since 1936, the mountain lands in the experimental area have been subjected to more than 300 summer rains. Most were of the short duration-high intensity "cloudburst" type. Rainfall rates for 5 minutes have been as high as 8.50 inches per hour. (*5*).

No mud-rock floods developed in any of the intensively treated watersheds under the impact of these rains. During the most intense rains, the steady summer flow of the streams from the intensively treated watersheds as well as from

the undamaged Centerville Watershed was interrupted by only short duration surges. The maximum discharges of 2 to 5 C.S.M. during these stormflow surges are less than most of the discharges which occur in the spring from snowmelt.

Mud-rock floods continue to occur on the untreated and only partially treated watersheds in the experimental area. Among these is Halfway Creek, a tributary of Farrington Creek. This stream flooded in 1923, 1936, and 1947. During the 1947 flood rain fell on the headwaters to a depth of 0.8 inch and at a maximum 5-minute rate of 4.98 inches per hour.

The mud and rock flood generated by runoff from this rain had a cross sectional area of 224 square feet. The discharge was estimated to be 2,000 C.S.M., or from 500 to 1,000 times greater than the nondestructive minor surges which now occur following heavier rains on streams draining the treated watersheds.

Watershed rehabilitation in Davis County, while effectively preventing destructive floods, has had relatively little effect on water yields. Annual discharge from the treated Parrish watershed has decreased about 0.1 area inch per year during the 22-year period 1936-1958. Most of the decrease occurred in the first 11 years. The greatest monthly decreases have occurred in March, April, and May, during snowmelt. June flows have increased slightly. Flows in other summer and the fall months are practically unchanged.

The upstream flood control measures used in Davis County have been applied in recent years on other damaged watersheds in Utah, Nevada, and Idaho. Effectiveness of the restoration work on those areas will not be known until the watersheds are subjected to torrential rains. However, 22 years' experience in Davis County gives reasonable expectation of a high degree of control over summer rainfall runoff with but little change in water yields.

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Watershed Improvement in the Tennessee Valley

Richard Kilbourne

THE TENNESSEE VALLEY covers some 26 million acres in 125 counties of seven states. It lies in a region of relatively high rainfall—52 inches a year on the average. From 6,000-foot peaks in the rugged Southern Appalachians of western North Carolina, the Valley drops south, west, and then north to an elevation of 302 feet at Paducah, Kentucky.

Over 54 percent of the Valley (14 million acres) is forested. And another million acres of open, idle, and eroding land is generally recognized as being in need of reforestation. Private forest owners number 245,000 and they control 11.5 million acres. Only one percent of the private holdings exceeds 500 acres in size; three-fourths average less than 50 acres apiece. The 18 percent of forest land in public ownership is chiefly in national forests, national parks, and military installations. TVA owns less than 170,000 acres of forested land along the Tennessee River and its tributaries.

The plan for controlling water in the Tennessee River and its major tributaries is based on an integrated system of 31 dams and reservoirs. They provide 12 million acre-feet of flood storage capacity during flood seasons, a 650-mile navigation channel from the Ohio River to Knoxville, and about 15 billion kwh of electric power annually.

While these dams and reservoirs were built and are operated for flood control, navigation, and power production, the waters and shorelines also serve more than a hundred industrial plants with investments of about $750 million. Investments in recreation facilities on TVA reservoirs by individuals, states, and local organizations now total $82 million and in 1958 the reservoirs attracted 36 million person-day visits of a recreational nature.

Backing up and supplementing its river control program, TVA also participates in cooperative programs aimed at protecting and developing the watershed. This of course includes a vigorous and effective cooperative program in the agricultural phases of watershed protection and improvement, but this paper will be limited to TVA's forestry and tributary watershed activities.

Erosion Control and Reforestation

Under the resource development provisions of the TVA Act, first attention was given to the two most obvious watershed problems—erosion and fire. In the early thirties over 2 million acres were eroding. Soil losses were as high as 30 tons per acre per year in some critical areas. The best way to reclaim this land, and in most cases the only way, was through reforestation.

Since the bulk of the eroded land was in private ownership, cooperative programs of education and demonstration were undertaken. These were supplemented by assistance from CCC camps (1934-1942) and trees and technical help from TVA. With termination of the CCC, the work was continued through cooperative arrangements with the seven Valley state foresters and the Valley state agricultural extension services. In recent years the ASC and Soil Bank programs of the Department of Agriculture have contributed to progress.

About 1955, the state forestry agencies began to expand their nursery facilities and put increased emphasis on reforestation. New and expanding pulp mills were creating bigger and better markets for pulpwood and strengthening the incentive to plant trees. In addition, many of the early pine plantings were ready for their first pulpwood thinning by the middle fifties, thus providing effective demonstrations of the economic value of reforestation.

The idea of planting trees for erosion control is now widely accepted as good business. Over 500,000 acres in the 125 Valley counties have been reforested. And of this total, between 300,000 and 350,000 were eroded. Some 50,000 landowners have been involved in this first simple step toward better watershed protection in the Tennessee Valley.

Fire Protection

In the early thirties less than half of the forest land in the Valley had organized state fire protection. And the quality of protection left much to be desired. According to best estimates, the Valley averaged 10,000 fires a year and close to a million acres burned.

TVA devoted such resources and help as it could to assist the Valley states extend organized protection and improve its quality. Initially the TVA-CCC camps helped with fire suppression. TVA foresters, in cooperation with the Valley states, conducted over 6,500 fire preven-

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tion meetings, attended by some 800,000 people. TVA funds and personnel were made available on other projects aimed at solving special problems or testing new methods. These included intensive studies of fire cause, detection planning, fire danger rating, fire damage demonstrations, and justifiable cost of fire control.

The Valley state forestry divisions have done an outstanding job in fire control. Today 95 percent of the Valley forest area is protected. During the past five years the burn on protected area has averaged 0.39 percent per year. Size of the average fire has been cut to 13 acres. Fire incidence, however, is still relatively high. The five-year average is 29 fires per 100,000 acres per year. Intensive fire prevention campaigns are needed in local areas of high incidence.

Other Watershed Protection Activities

While the forestry phase of TVA's watershed protection and development program began with erosion control, reforestation, and fire protection, these were later supplemented by two other approaches—better forest management and logging practices, and reduction of woodland grazing. These two activities are currently receiving major emphasis.

With adequate protection from fire and grazing, forest stands in the Valley recover rapidly from harvesting operations if given half a chance. Within five to ten years the naturally restored ground cover is adequate for good watershed protection, although this does not necessarily hold true for optimum economic returns. And of course restoration of good forest floor conditions may take longer, perhaps as much as 15 years.

How the logging is done is the determining factor. Most watershed damage resulting from harvesting operations can be traced to skidding and road construction and maintenance. Forest Service investigators at Coweeta Hydrologic Laboratory, near Franklin, North Carolina, measuring soil loss from a single skid road on a 30 percent slope, found it ran as high as 100 cubic yards per mile in a 60-day period. The stream draining a logged watershed carried over 20 times as much silt as a stream draining an adjacent unlogged watershed.

Using watershed protection specifications developed at Coweeta, TVA and state foresters in 1949 joined with the city of Waynesville, N. C., in a water and timber management demonstration on the city's 8,000-acre municipal watershed. After 10 years, construction of 50 miles of logging road, and removal of 13 million board feet of timber, state public health officials found no damage to water quality.

All timber sale contracts contained rigid road specifications. Roads had to be located away from streams, on upper slopes and ridges. Grades had to be kept below 10 percent wherever possible; 20 percent was the absolute maximum. Water bars were required at frequent intervals, and road ditches were allowed only where there was permanent seepage. Road banks had to be kept vertical, with the least possible disturbance of overhanging vegetation. Where permanent water courses crossed a road, a bridge or culvert had to be built. Since most roads were at high elevations, uphill power skidding was necessary. Downhill animal skidding was limited to short distances and gentle slopes.

This project has been reported[1] and it has been visited by many people. The lessons learned here are currently being applied on five other municipal watersheds in western North Carolina and one in Tennessee.

Woodland grazing, particularly in farm woods, is damaging about 15 percent of the forest land of the Valley. A survey now under way is aimed at discovering the underlying basic reasons for woods grazing and providing a basis for an effective action program in cooperation with landowners and agricultural extension services.

Tributary Watersheds

TVA's tributary watershed program, in which forestry plays an important part, is concerned with better watershed and resource management. It involves both research and demonstration. And since the problems encountered are usually local in nature, state and local agencies are encouraged to take part in the research and assume leadership in the demonstration projects.

White Hollow, a 1,750-acre experimental watershed in east Tennessee, was set up in 1936. After 15 years of reforestation, protection, and management, peak summer stream flows were reduced 92 percent. Storm runoff was prolonged as much as 500 percent. Despite an increase of timber volume from 4.4 to 7.1 million board feet, total water yield was not significantly affected. Twenty-year forest cover data were collected in 1956. Hydrologic measurements will be continued as timber management practices are applied.

Another experimental watershed is 88-acre Pine Tree Branch in western Tennessee. Beginning in 1941, this watershed went through a five-year calibration period and was then reforested following construction of erosion control devices such as check dams. In five more years surface runoff had been reduced 35 percent. Peak storm discharge had been cut to one-fourth of its original volume. Soil loss had been reduced from 24.2 to 2.5 tons per acre per year.

Parker Branch watershed in western North Carolina contained 47 operating farms. The plan here was to bring these farms to maximum productivity and measure the effect of land-use changes on water yield and soil loss. Initial calibration was begun in 1953; the action phase has been completed; evaluation is now in progress. The major forestry contribution has been development of a method of applying basic input-output data for determining the most profitable com-

[1] Tennessee Valley Authority. Guide for watershed management—the second decade. June 1959.

bination of forestry and agriculture on a given farm.

Three watersheds are included in the demonstration category—85,000-acre Chestuee Creek in east Tennessee, 193,000-acre Beech River in west Tennessee, and 127,000-acre Yellow Creek in northeast Mississippi. In both Tennessee and Mississippi, state agencies have assumed responsibility for leadership in watershed activities. TVA assists in general planning and provides technical help and other facilities as required.

Substantial land-use changes in Chestuee Creek watershed have brought about a 48 percent reduction in the silt load of Chestuee Creek. Organized fire protection was extended to the watershed by the state and 2,800,000 trees have been planted. Since 1935, landowners in Beech River watershed have reforested close to 20,000 acres. State fire protection was inaugurated and an intensive fire prevention campaign has reduced fire occurrence to a minimum.

Watershed protection and timber production—TVA's two forestry goals — can be achieved without conflict of interest. Management practices that yield optimum, long-term financial gain for the forest owner also insure adequate protection for watersheds.

Watershed Management in the Muskingum Watershed Conservancy District

Bryce C. Browning

"THE Muskingum Conservancy District is the nation's Number One example of how a watershed may be developed and managed for the public benefit." So stated E. H. Taylor, former senior associate editor of *Country Gentleman* magazine. But it was the flood control program of the Miami Conservancy District which paved the way for the Muskingum project. Located on opposite sides of the state these two developments seem to make Ohio a pioneer in watershed management.

It was the great flood of March, 1913, which initiated Ohio's leadership in this important field. The cost, some 500 lives and 300 million dollars in property, was high. But an immediate result was the decision that means must be found to control future floods. It seems probable a lesser shock would not have produced the same results.

Dayton, principal city of the Miami Valley, had suffered the greatest loss. It was her citizens who promptly pledged 2 million dollars to learn how flood control might be attained. Specialists in both engineering and law were employed and extensive studies undertaken. On February 5, 1914, less than a year later and primarily through their efforts, the Ohio Conservancy Act was passed. Its basic purpose was to permit all citizens of a flood affected area to work together in the planning, financing, and management of such a project. Thanks to the broad vision of their leaders it also made provision for every recognized phase of watershed management and for cooperation with state and federal government.

Under the leadership of Dayton citizens, the Miami Conservancy District was promptly organized and the construction of its works initiated. Due to conditions beyond the control of its directors their program was limited to flood control. Completed in 1921 it was the world's first such project. Based on the following years of experience it has accomplished all that its designers promised. It also provided a major incentive for similar activities in other watersheds both in Ohio and other states. There were like effects at federal levels as well as in certain other countries.

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The Muskingum Watershed

The valley residents of the Muskingum Watershed were slow in recovering from the 1913 flood. There had been two previous great ones within a 30-year period and each time the comeback was more difficult. Their area, one-fifth of the state, was much greater than

the Miami and the cost of control seemed so great as to make it impossible. It was not until 1927, six years after completion of the Miami project, that the Zanesville Chamber of Commerce initiated the first flood control study in the Muskingum. Without the example set by the Miami people it would not have been undertaken. At the advice of Arthur E. Morgan, guiding genius of the Miami project, their program was broadened to embrace water conservation and recreation as well as flood control. Of equal significance was the influence of two other great American conservationists, George H. Maxwell and Hugh H. Bennett.

It was George Maxwell who led the campaign which, in 1902, resulted in passage of the National Reclamation Act. To those acquainted with his more than 40 years of dedicated public service he was our nation's greatest leader in the water conservation field. In 1929, at the request of the Zanesville Chamber of Commerce, he became director of its Soil and Water Conservation Commission. With the scientific backing of Dr. Bennett, later chief of the Soil Conservation Service and foremost authority in the soil conservation field, he convinced the Muskingum Valley people that floods, drouths and soil erosion were common problems and that control must start where raindrops first strike the land. That reservoirs, while essential to flood and drouth control, must be supplemented by upstream engineering.

Conservancy Established

It was on June 3, 1933, following announcement by President Roosevelt of his proposed "great Public Works Program," that the Muskingum Watershed Conservancy District was officially organized. Under provisions of the Ohio Conservancy Act this was accomplished through action by a special conservancy court which includes a representative from each of the affected counties. The first major effort of its three-member board of directors was to secure federal funds to aid in the construction of their proposed project. All costs associated with the 6-year promotion of the program, including the first engineering study by the Dayton-Morgan Engineering Company and various special engineering reports, had been paid for by Zanesville citizens. In 1930, with the assistance of a $10,000 state contribution, a second and more detailed engineering study had been initiated. Following organization the local costs associated with its construction were provided through assessments against the affected counties, municipalities and individual land owners.

As a part of their program the directors of the Muskingum District established certain basic policies which have since been followed. Their first decision was to continue payment of the regular tax on all lands which they might acquire. This was followed by an announcement that they would operate on the minimum of tax income. To this end they promised not to duplicate the work which another agency of government would assume. As the possibilities of the program became clearer they determined to develop it so as to provide the maximum of public benefit.

In December of 1933 the Federal Emergency Administration of Public Works approved a grant of $22,590,000 for the construction of the Muskingum project. This was the only one of its nature which was so aided. It was contingent upon the District assuming all costs of lands and damages and for the relocation of the affected highways. Just a few months later, through the efforts of Conservancy District officials and friends, the Ohio legislature appropriated 2 million dollars to assist in acquiring the necessary lands and easements. It also assumed responsibility for the relocation of all affected highways.

The Muskingum project was officially dedicated in July, 1938. After 13 months of District operation the U. S. Corps of Engineers was authorized by Congress to assume responsibility for the flood control phase of its program. This was in keeping with flood control policies adopted by Congress after construction of the District project had been initiated. Having served as its construction agency they were well qualified. With the exception of the various dam sites, the District retained fee title in all the affected lands and responsibility for the conservation and recreation phases of its program. The following years of cooperative management have seemed highly satisfactory to each of these agencies. The resulting benefits in economy of operation and improved facilities seem highly desirable from the public standpoint.

It was not until 1937, four years after the District's organization, that the Conservancy Act was amended so as to permit recreation operations. But District officials had recognized this potential and given extensive study to it. To this end they had attempted to acquire substantial margins of land around each of the permanent reservoir areas. This amendment permits the making of assessments against the affected property owners for the financing of recreation improvements as well as for their maintenance and administration.

Construction of the Muskingum project necessitated purchase of 65,000 acres of land and the securing of flowage easements on an additional 38,000. Of the area purchased 16,000 acres are covered by the 10 permanent lakes. A major problem was to control soil erosion and thus prevent critical siltation of the water storage areas. It was realized that landowners in the watersheds back of the reservoirs could not be expected to improve their land use except as a good example was set by the District.

Through the assistance of Soil Conservation Service land use studies were made of the 49,000 acres of District-owned land outside its permanent lakes. They were found to be generally hilly and badly eroded. All had originally been in timber and some 15,000 acres remained in low grade woodlots. It was their recommendation that both this 15,000 acres and an additional 20,000 be utilized for forest production. Forestry thus

became the District's major conservation activity. Nearly 6 million trees have already been planted and substantial areas of the original stands have been improved.

With the exception of the areas best suited for forestry, most of the crop lands in the dry reservoirs have since been sold to help retire the flood control debt. All such sales are subject to the standard flood water storage easement. Plans now under way provide for the early completion of both the planting and woods improvement programs. This involves the planting of an additional 6 million trees. All costs of both the forest planting and improvement programs are paid out of income from the land operations. Much of it is from the sale of timber and Christmas trees.

Basic Policies

Previous reference was made to four basic policies established by the District's original board of directors. The first of these had to do with the payment of taxes. During the ensuing years it has paid the same land tax as any private owner. To date this totals nearly $600,000. The second policy was to operate on the minimum of tax income. With the exception of a one-half year maintenance levy made in 1939 the District has operated without tax income of any kind. It is said to be the only governmental agency which both pays taxes and operates without tax income.

The District's third policy was to not duplicate the work that another agency of government would do. This is largely responsible for its financial success. During the depression period as many as 20 different agencies of government were assisting. While many were of an emergency nature and later terminated, there are ten whose assistance has been continuous. With exception of the flood control program, this is accomplished under regular budgets and without any increase in public cost.

The fourth and final of the District policies was to develop its facilities so as to provide the maximum of public benefits. It was as a result of this policy that ten of the reservoirs were designed to provide water conservation as well as flood control. This was accomplished without any reduction in the required flood storage. They provide a total water area of more than 16,000 acres and, at the time of completion, increased Ohio's inland lake area by 50 percent. The shore line around each of the 10 lakes, totaling more than 365 miles, was perpetually dedicated to public use. This same dedication applied to the entire area of its various islands. In addition, income producing recreation operations were limited to 20 percent of the remaining land areas. It is believed that it may have pioneered in this particular field.

Benefits Derived

Within the past year estimates have been made of the dollar value of the benefits resulting from the District's operations. Including the floods of January and February, 1959, the flood protection benefits have a total value of some 64 million dollars. The original cost of the project was 48 million. Based on tables provided by National Park Service, the recreation benefits during this same period have a value in excess of 15 million dollars. Major recreation improvements already made, or in process of being made, represent a total cost of some 2 million dollars. All such improvements are financed out of operational income and without taxation. With expanding populations and increased use the ratio of recreation value increases each year.

Reductions in siltation resulting from the District's forestry program and from improved land use on adjoining privately owned lands has greatly extended the useful life of the reservoirs. This is most apparent at Leesville Lake where the forestry program was first completed. According to original estimates, serious reductions would have occurred there within a 300-year period. Recent studies indicate this may be extended a thousand or more years. With the completion of the forestry program in the other reservoir areas and the continuing improvement in general land use practices it is believed they will all function effectively for an almost indefinite period. In the meantime the timber value being created is an ever increasing one.

In addition to the values already named the Muskingum Lakes provide one of Ohio's greatest man-made water conservation assets. Just how great its future value may be is difficult to estimate. But in combination with the other established benefits it provides ample justification for the Muskingum project and would seem to encourage the development of similar ones elsewhere.

Timber and Water—Twin Harvest on Seattle's Cedar River Watershed

Allen E. Thompson

For over half a century the water resource and the timber resource of the Cedar River Watershed have been utilized for the benefit and economic well-being of Seattle, Washington, and neighboring communities on Puget Sound.

In the early 1890's Seattle, realizing need for an abundant supply of pure water, started developing Cedar River as its source of domestic supply. The first water was delivered to the City in 1901. Since that time the river has supplied, by gravity, all the water for the city, and in recent years much of the surrounding metropolitan area as well. The population presently served is 650,000, roughly one-fourth the population of the state. It is estimated that in the future, wih full development of storage possibilities and regulation, Cedar River will be capable of serving a population of 1,000,000.

The term "Cedar River Watershed" denotes all of the drainage area of the Cedar River above the intake of the municipal supply at Landsburg. This is a roughly rectangular area. It extends eastward from the Landsburg intake for an airline distance of 25 miles to the crest of the Cascade Mountains in central Washington. With a maximum breadth of 8 miles it has an area of 143 square miles, or 91,500 acres.

The eastern two-thirds of the watershed is mountainous. Here the streams are swift-flowing, many in narrow, steep sloped valleys. The summits of flanking ridges rise to elevations 4 to 5,000 feet above sea level. At midpoint in the watershed is Morse Lake (formerly Cedar Lake), a large, natural lake 4½ miles long by ½ mile in width, which has been developed by an outlet dam to increase primary water storage for the City. The western third of the watershed is characterized by rolling hills and benchlands with a gradual fall in elevation to 520 feet at the Landsburg intake. On this western portion, below elevations of 1,600 feet, are found extensive deposits of morainal material left by glaciers.

A few large areas of barren rock are found in the higher mountains. Otherwise the watershed is well covered with a soil mantle that is quite generally deep, loose, and permeable and which readily permits the rapid absorption and percolation of precipitation. The soil, being quite productive, has and can continue to support a heavy forest growth, even to the summits of most of the high mountain ridges. The predominating type is Douglas-fir which covers most of the lower elevations and extends well up on the slopes. On higher elevations a mixed type of western hemlock, Pacific silver fir and Noble fir predominates. Occasionally pure types of one of these three species occur.

The watershed lies in a region of moderate to heavy precipitation; annual rainfall varying from an average of 54 inches at the Landsburg intake to 104 inches farther eastward in the mountains at Morse Lake. Most precipitation occurs during the fall, winter, and spring, when there may be occasional storms with heavy and prolonged periods of precipitation that create high stream level and rapid runoff conditions. In the winter months at the higher elevations snow accumulates to form, by spring, a well packed layer of snow and ice several feet in depth. This snow pack, having a water content of 40 percent or more, is an important factor in sustaining streamflow well into the summer dry season of July, August, and September. In all respects the Cedar River Watershed is an excellent one for both the production of domestic water and timber.

Water Production

The quality and purity of the water at the supply intake is such that only a minimum of purification treatment is required. This treatment consists of light application of chlorine, as the water enters the supply lines leading to the City, followed by secondary chlorination on leaving the reservoirs and entering the distribution system within the City. Filtration is not necessary under present conditions existing on the watershed. During the summer months water is withdrawn directly from the river into the City supply lines, an operational procedure which is possible because of the high degree of purity, quality and clearness of the water.

A secondary storage supply for the City is maintained in Lake Youngs, a large 3½ billion gallon reservoir, located along the route of the supply lines to the City. Under normal operating conditions during the rainy season, water from the river is discharged into Lake Youngs where it is retained for a period of time before entering the supply lines for the City. This removes any slight turbidity which may exist in the water being diverted from the river. Under

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stormy conditions, with heavy runoff and resulting high turbidity in the river, no water is withdrawn at the intake. During this time the City is supplied with clear water from storage in the Lake Youngs reservoir. Later, when the river water is again running clear or with very low turbidity, Lake Youngs' storage is replenished. These operational features are mentioned because they are significant in determining procedures of work and activities in the watershed above.

Land Acquisition

At the time of starting development of the water supply the City also began acquiring the watershed lands to protect and control the purity and quality of the water. While the most rapid acquisition of lands occurred in the years 1905-1915, the program has been a continuing one with additional lands still being acquired from time to time. The City ownership now comprises about 65,500 acres, or 73 percent of the watershed land area. When the present land exchange program is carried to fulfillment, and under provisions of present logging agreements, the City will acquire complete ownership of the watershed when the remaining stand of virgin timber has been harvested.

Some of the watershed lands were logged prior to acquisition by the City. With most of the private timbered lands the City pursued the policy of acquiring land only, the timber and the right to log being retained by the owner with the City coming into full possession on completion of logging. In making these timber reservation agreements the City set forth such stipulations and restrictive clauses as deemed necessary to govern the logging operations, so as to protect purity and quality of the water supply. Private timber yet to be harvested covers about 12,000 acres of City-owned land.

In the vicinity of Morse Lake, however, the City did acquire some 8,000 acres of timber, as well as the land. Sales of this timber have been made from time to time.

Nature of Forest Cover

In its virgin state the Cedar River Watershed was covered with a dense and continuous old growth forest. Logging operations were already in progress in 1901 when the City first started use of the Cedar River supply and have been continuously in operation since. The result of timber cutting over this period of 60 years or more has been an extensive, continuous, and ever-increasing area of cutover forest land. In the meantime, reforestation of these lands has been accomplished chiefly by natural processes but with some planting in the case of severe burns. Now, with the exception of the most recently logged areas, which are in the process of reforestation, the Cedar River Watershed continues to be covered with a forest, but one in which many age groups of young, second growth timber are represented as well as the remaining virgin old growth timber.

These second growth forests, owned in one solid block by the City, possess all the attributes of watershed protection possessed by the virgin forest before them. When looked on from a height they extend unbroken for mile after mile, and are an inspiration to see.

Ownership of the present uncut, virgin commercial forest area of approximately 32,500 acres, supporting an estimated timber stand of a billion and one-half board feet is as follows: City of Seattle, 8 percent; national forest, 52 percent; and private, 40 percent. These ownerships are distributed in a checkerboard pattern, and lie entirely in the mountainous eastern portion of the watershed.

Administration and Management

Since 1924 Seattle has had a policy of sustained yield management for its watershed forest, set up and authorized by City Council ordinances. Within the Water Department of the City government is the Forestry Division. The responsibilities of this division cover forest management and the performance of work connected with other watershed activities. The forester and his staff of workers are permanent civil service employees of the City. The work of this division is versatile and varied. The City furnishes its own protection from fire for its lands in the watershed, operating fire lookouts and suppression crews and maintaining fire fighting tools and equipment. Fire hazard reduction activities have been carried on. A network of access roads has been constructed and permanent fire trails have been built. Areas with insufficient natural reproduction, resulting from severe early burns, have been planted using trees grown in the department's own nursery. Timber sales have been made in the past and are now almost continually in progress. Sales have been in old growth timber, in stands of second growth alder, and in second growth coniferous forests. The latter are usually for transmission and other right-of-way clearing and for salvage of snags, windfalls, and residuals left by the early loggers. An experimental start on thinnings in second growth can be enlarged into commercial sales as soon as economically feasible.

In the protection of the watershed from fire, and related activities, close cooperation is maintained with the Washington State Department of Natural Resources whose protection district surrounds the western portion of the watershed and with the U. S. Forest Service where national forest lands are intermingled with the City's—in the mountainous eastern portion of the watershed lying within the boundaries of the Snoqualmie National Forest.

Management activities are centered in a new and modern group of headquarters buildings recently constructed in the City-owned community of Cedar Falls in the watershed.

The watershed is closed to the public with no form of recreational use permitted. Sanitary patrol is a responsibility of the Sanitation Division of the Water Department.

Funds for the operation of the Forestry Division and for capital

improvements are a part of the budget of the Department of Water and come from the water and other revenues. They are not dependent upon timber sale income. Revenues from the sale of timber are treated as a return of capital invested, are credited against the capital cost of the watershed and are expected in time to retire the cost.

Harvest of Privately Owned Timber

For the past 15 years timber harvesting and attendant logging operations have been conducted in old growth, privately owned timber under the Cedar River Watershed Logging Agreement. This is a contract between the City and the three private timber owners represented on the watershed. Made in 1945, it provides for the cutting, over a 40-year period, of the remaining stand of old growth timber. Since 1945 logging operations have been reduced to one major and continuing one. This has greatly simplified the responsibilities of sanitation, forest protection, and watershed management.

There are many provisions to the logging agreement. The average annual cut is limited to 35 million board feet, the sustained annual yield capacity of the watershed. Cutting is to be in accord with the best forestry practices and carried on so as to protect the purity, quality, and quantity of the water supply. Both sanitary and fire regulations are provided for. Provision is made for the use of City-owned roads where needed in transporting timber products, and for the construction of additional roads by the operator. Under this agreement the private owners have constructed a road system some 125 miles in extent, covering their operating areas. Additional roads, needed for havesting the remaining virgin timber, are being built at the rate of about 10 miles annually.

In operations under the Watershed Logging Agreement the method of timber harvesting has been that of clearcutting in the form of strips or blocks with bordering stands of timber serving as seed sources for reforestation. Because of the checkerboard pattern of ownership, cutting boundaries often have to follow property lines. High lead yarding has been found satisfactory and is the principal method of logging. Tractor logging is used on very limited areas, where topography and soil formations are such that there is no danger of damage from compaction or erosion. Log transportation is by truck.

In timber cutting operations consideration is continually being given to avoidance of practices which would create sedimentation and impair the water quality. Logging settings are laid out to avoid yarding of logs across or along main stream channels. Roads are located as far from stream channels as possible, and so constructed and drained as not to cause erosion.

Logging slash has been burned on those areas requiring it in the interests of fire protection, but on many areas where conditions were favorable the slash has been left in the interests of better watershed protection, quicker reforestation, and maintenance of site quality. Closer utilization and relogging to recover small sized material left from major logging operations are greatly reducing the volume of slash and consequently the problems connected with its disposal.

Natural reforestation following logging has, on the whole, been quite satisfactory, both as to rapidity and adequacy of restocking. This has been so even on the extensive cutovers of the early railroad logging days. Some limited areas of slow or poor restocking occur, which seem to be due to adverse site conditions rather than to lack of seed supply. It has been considered that, on the average, a regeneration period of five years is needed to secure adequate restocking. This is now being shortened through artificial seeding.

During the past ten years of timber cutting under the Cedar River Logging Agreement the average annual cut has been 32,791,000 board feet, with an average of 547 acres cut over annually. Logging operations are on a seasonal basis, for the heavy snows at higher elevations cause winter shutdowns of 3 to 4 months.

National Forest Sales

A few sales of national forest timber have been made by the Forest Service to the private owners who then operate under the Forest Service timber sales contract and also fulfill their obligations to the City under the Watershed Logging Agreement. Because of the checkerboard pattern of timber ownership, and because the Watershed Logging Agreement is between the City and the private owners only, there is need for a permanent road use agreement and a cooperative timber management plan between the City, the Forest Service, and the private owners so that national forest timber can also be included in the harvest cut on the watershed. Such road use agreement and management plan will have the effect of amending or revising the present Watershed Logging Agreement. The difficult problems involved in developing the road agreement and management plan are well on their way toward resolution, and it is expected that workable and satisfactory agreements soon will be achieved. Exchange of lands between the City and the Forest Service, which will block up and consolidate ownerships (one exchange has been consummated), will be continued in connection with the timber management plan.

Sales of City-Owned Timber

Sales of City-owned timber have been made from time to time. Each sale must have approval of the City Council. Sales are small, running from 2 to 10 million feet. They are for specific stands of timber, with a definite time limit, and made on a log scale basis. Prices are determined by the City, using stand-

ard appraisal procedures which are supplemented by recommendations of a board of qualified appraisers so as to reflect current market price.

Operations in these second growth forests are not specifically provided for in the Cedar River Watershed Logging Agreement. However, with increasingly large areas attaining the age and size that thinnings or other cuttings can be made and with the market rapidly developing for such products, the management of second growth is attaining greater significance. A small start on sales of this material has been made. Studies on the growth and yields that can be expected are under way. Pruning of crop trees for the production of high grade logs has been started. Plots for the study of thinning procedures and yields have been established. The problems of brush control and of stand improvement through chemical control of weed trees are being given consideration.

The second growth hardwood stands, not too extensive in area, are being managed with the objective of conversion to conifers wherever possible. The principal species is red alder which matures at from 45 to 50 years. Its lumber has a fairly good market, principally for use in the furniture industry. Several alder sales have been made, with the areas clearcut, and where sites are suitable Douglas-fir or western hemlock have been planted the first season after logging.

Compatible Uses

Data on precipitation and stream flow are continually being secured by the City of Seattle, and tests on the turbidity, quality, and purity of the water are constantly being made. All information indicates that present timber cutting practices have had no discernible effect upon runoff or the quality and purity of the water supply. Also timber cutting has produced no appreciable erosion on the watershed. Seattle's opinion is that controlled use of the timber resource is in no way incompatible with the primary use of the Cedar River Watershed for domestic water supply development.

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Watershed Management in the Department of the Interior: Three Case Studies in Cooperation

G. F. Horne

THE Department of the Interior, with administrative jurisdiction over approximately 548 million acres of public lands, has been appropriately identified as the "Nation's landlord." Among the responsibilities which go with this title is that of managing these lands for the maximum use of water, consistent with other essential resource uses and available funds.

More than 750 community watersheds are included on public lands administered by the Department of the Interior in the 17 western states.

Directly or in cooperation with other federal, state, local, or private agencies, the Department has undertaken programs involving many aspects of watershed management. Such programs include research, watershed protection, land rehabilitation, water development, modification of vegetative cover, irrigation, flood control, hydroelectric power, and recreation.

For more than half a century the Department has been making basic water studies including those related to the nature, quality, location, quantity, and availability of water; losses, effects of other resource management practices, current uses, future needs, and conversion of brackish and saline water to fresh water.

Interior agencies with major roles in water and watershed management activities include the Bureau of Land Management, Bureau of Indian Affairs, Bureau of Reclamation, Bureau of Sports Fisheries and Wildlife, Bureau of Commercial Fisheries, National Park Service, and Geological Survey.

The remainder of this report will be limited to comments on three watersheds; two involving lands administered by the Bureau of Land Management, and the

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third, Indian lands managed by the Bureau of Indian Affairs. The first, located in north-central Wyoming, includes rangelands heavily overgrazed, severely eroded, and rapidly losing their vegetative cover. A combination of rehabilitation practices applied by the Bureau of Land Management soon restored the watershed to a favorable condition. The second, located in northwestern Oregon, involves a high-value virgin forest used almost exclusively as a municipal water supply source. Cooperative efforts by the Bureau of Land Management, and other interest groups, and appropriate attention to forest management-watershed practices, demonstrated that compatible use of timber and water in the area is practical. The third area concerns rangelands in northern Utah. Abused by long-term overgrazing, cultivation, and lack of a suitable management plan, cooperative efforts by Indian livestock operators and Bureau of Indian Affairs technicians in developing and using conservative range-watershed management practices eventually restored the area to a high productive capacity.

15-Mile Creek Community Watershed

The 15-Mile Creek Watershed located west of Worland, Wyo., contains approximately 380,000 acres, 84 percent of which is publicly owned. Badlands, narrow valleys, valley basins, and rolling hills are general topographic features of the drainage. Elevations vary from 4,600 to 6,000 feet. Average annual precipitation at Worland totals 8.2 inches, with 5.86 inches occurring between April and September as high intensity storms. The soils are primarily derivatives of sandstones and shales and are classified as sandy or silty clay loams. They vary from shallow to deep and are generally underlaid with shales and sandstone. Infiltration rates range from slow to medium.

Because of its comparatively sheltered aspect, the 15-Mile Creek Drainage was considered the favorite area in the Big Horn Basin for wintering sheep. The same area was also used by cattle on a year-round basis. Thus, continuous, intensive, and largely unregulated grazing of the area eventually led to loss of much of the grasses and shrubs, encroachment of some more hardy annual weeds, and severe sheet and gully erosion.

A flow recording station installed on 15-Mile Creek near its confluence with the Big Horn River in 1951 indicated that during the first six months of its operation, an estimated 415,134 tons of silt passed the station. A peak day's flow during a 48-hour rainstorm with precipitation of 1.39 inches of rain at Worland produced 394,000 tons of silt which passed the station during this period.

In 1952, following an intensive study of the watershed and the factors considered contributory to the prevailing conditions, a plan was designed and adopted for rehabilitation. The program included construction of detention dams with storage capacities to hold runoff from storms of 50-year frequency and to release water at a controlled rate; a waterspreading system consisting of a series of dikes at approximately 2-foot vertical intervals and constructed on the contour to direct the flow of water over relatively flat areas, to dissipate flood flows, and increase the soil moisture for plant growth; contour furrows to reduce runoff and increase percolation; and installation of numerous watering places for livestock to promote uniformity in forage utilization. The waterspreading and contour furrowed areas were then seeded to grass, and finally grazing was closely correlated with the established carrying capacity of the range.

Since the area also served as a habitat for wildlife specific measures for improving such use were also included in the management plan, including fencing of small areas to exclude livestock and to provide food and shelter for upland game birds.

By 1956 approximately 75 percent of the scheduled work for the 15-Mile Creek Watershed had been completed. While full benefits are not yet realized, it is estimated that forage production has already been increased by 100 percent. Siltation, erosion and other losses have been reduced proportionately.

In order to provide a continuing record for evaluating the plan and its practices, study plots have been established on typical sites—on treated and untreated areas.

Oregon City Watershed

For almost a half century the Oregon City Watershed, located south and east of Portland, Oregon, has attracted attention as a municipal water supply area. By a special Act of Congress in February, 1920, (41 Stat. 405) the federal government provided that certain publicly owned lands located in the watershed would be so managed as to assure protection of the area as a municipal water supply source.

In 1930 and 1932 privately owned lands in the watershed were acquired by the federal government through exchanges and placed under the administrative jurisdiction of the General Land Office, now the Bureau of Land Management in the Department of the Interior, to further assure that the watershed would be protected.

The watershed, consisting of approximately 18,600 acres, including 2,000 acres administered by the Bureau of Land Management with the remainder under the jurisdiction of the Forest Service or private owners, supports an estimated one billion board feet of currently merchantable timber. Elevation ranges from 600 to 4,800 feet. Annual precipitation averages 100 inches with heavy accumulations of snow at the higher elevations.

Since the watershed is timbered with mature Douglas-fir and associated species, in many areas averaging more than 100,000 board feet per acre, there has been considerable interest in logging operations in the watershed. Applications to purchase timber in the

watershed administered by the Bureau of Land Management were submitted from time to time during the period 1939-1942. All were rejected pending development of logging techniques and plans which would adequately protect the watershed.

In November 1942 three small sales involving approximately 250,000 board feet of noble fir and 6 acres for each sale area were made under the war emergency program to supply aircraft materials. The contracts for these sales, located in the upper reaches of the watershed, prescribed selective cutting, minimum road construction, and other practices designed to minimize disturbance of the stand and the soil. During and subsequent to logging operations the sale areas were observed closely to determine the adverse effects, if any, on the water supply. None was discernible. In the interim detailed plans for road locations, sale boundaries, logging practices, sanitary requirements, etc., for possible future timber harvesting operations in the watershed were being considered by Bureau of Land Management foresters. Some local interests were strongly opposed to any logging in the watershed. They contended that the quality, and possibly the quantity, of available water would be adversely affected by logging operations.

Following consultation with other public and private agencies, namely the Public Health Service, Oregon State Board of Health, Oregon City Water Board, and other municipal officials, the Forest Service, and prospective timber purchasers, a general management plan and conditions of sales were approved for a trial period. Of particular interest were the special terms and conditions of the Bureau's timber sale contracts. These included provisions for requiring clearcutting in staggered settings; cable yarding; prompt, controlled burning of slash; reforestation of cutover areas; minimum road grades and curves; special culvert and water diversion measures; chemical toilets, etc.

The apparent success of earlier and smaller sales led to larger sales in 1944 and thereafter by the Bureau of Land Management. Since its first sale in 1942 the Bureau has made more than 20 additional sales involving more than 42 million board feet of timber in the Oregon City Watershed. No appreciable adverse effects on the quality or quantity of water from the watershed have been observed to date.

This record of almost a decade of carefully planned and properly administered timber sales activities in the Oregon City Watershed is an excellent demonstration of land management for the concurrent use of its major resources. It is an outstanding example of coordination of public and private efforts in the total public interest.

Hill Creek Watershed

Located in northeastern Utah and consisting of approximately 350,000 acres, owned by the Ute Indian Tribe and administered by the Bureau of Indian Affairs, is the Hill Creek Watershed. Within this area elevations vary from 3,500 to 8,000 feet; precipitation ranges from approximately 10 inches in the lower elevations, to 20 inches at higher levels.

These lands were opened to homesteads in 1916 and numerous ranches were subsequently established. During the ensuing quarter-century the area was heavily grazed by locally owned livestock and migrating bands of sheep. A vivid illustration of the extent of abuse suffered by the watershed in this period is evident from the "before-and-after" condition of the main stream. In 1916 Hill Creek at the confluence of Hill and Willow Creeks was a clear, meandering stream with beaver dams and lush meadows. In 1940 at the same point a gully some 40 feet deep and 100 feet wide was its bed, and the stream, silt-laden during periods of flow, often contained no water during the summer.

Approximately at the same time the Taylor Grazing Act was passed (1934), it was determined that the Hill Creek Watershed would be purchased for use of the Ute Indian Tribe. From the period 1934 to 1940 most of the ranches on the Hill Creek were purchased by the government for use of the Indians. During that period there was a transition in use, in which all of the non-Indian-owned livestock were moved off of the area and at the same time the Indians started using the area with their livestock. Most of the area, except part of the winter range, was placed under the jurisdiction of the Bureau of Indian Affairs. Stocking was reduced in 1940 to approximately one-fourth of what it had been prior to 1934. The Indians and the Bureau recognized the past abuse, and, inasmuch as funds were not readily available for rehabilitation of the range, reduced range use to obtain improvement. Conservative stocking and management plans which provided for deferred rotation and seasonal use of the units have healed most of the scars of past abuse. Today Hill Creek has stabilized itself to where it is again a perennial stream and provides irrigation water for the ranches along the stream. Fish are now abundant in the stream whereas there were no fish in 1940. Sagebrush removal and seeding have been accomplished only on those areas where all remnant perennial grasses had disappeared. Through range management practices this watershed has been returned to its former high level of production of forage and the Indian livestock operators have an established economic return.

Northeast Municipal Watersheds

John M. Heilman

FORESTED MUNICIPAL watersheds in the Northeast, were generally established from about 1890 to the 1920's. During this period acquisition was considered important to produce a water free of contamination. With the general introduction of chlorine around 1915, expansion of and increase in numbers of municipal watersheds tended to decrease. Today, high quality raw water is sought as an additional factor of safety and palatability. This situation has been compared to the pasteurization of milk.[1] Sanitary conditions on the farm were of primary importance before pasteurization—when this proved effective, sanitary conditions were forgotten for a time, but today sanitation is very carefully controlled and provides additional measures of safety.

Municipal watershed purchase today is limited largely to areas of greatest danger to the raw water, namely wide marginal strips along reservoirs and streams.

According to the Northeastern Forest Experiment Station there are about 360 municipalities in the Northeast whose water supplies are furnished and protected by forested municipal watersheds or who possess forest-protected reservoirs. Pennsylvania has the highest number of watershed-reservoir forests, 98, while four states, Connecticut, New Hampshire, Massachusetts, and New York possess 54 to 48 areas.[2]

Since there is considerable variation in management practices and objectives on the various watersheds, a comprehensive picture may best be obtained by summarizing policies and practices of some of the larger cities.

New York City, with 1,519 square miles of watershed, owns 70,000 acres. After reservoirs, marginal strips, adqueducts, and structures are removed, there are 10,500 acres of forest, or about one percent of the drainage area. No forester is employed, and most of the work is done by labor not needed for other work. Plantation pruning and cleaning are for aesthetic purposes rather than cultural.

Boston, Massachusetts, employs a forester on its 86,392 acres, and its forest management policies give consideration to all phases of forestry. Logging, stand improvement, and thinning of 6,000 acres of pine plantations are receiving current attention.

Baltimore, Maryland, is practicing intense forestry under a professional forester on its 17,300 acres, six percent of the drainage area. About 150,000 board feet per month are cut with their own labor force, leaving 3,000 board feet per acre.[3] Management here, as in many watersheds in the East, is based on the principle of multiple-use. Baltimore's situation represents very well one of two distinct types of management. Here the municipal ownership is confined to areas adjacent to streams and reservoirs, and the condition of forest and roads is immediately important to water quality.

Baltimore does its own logging, burns all slash, has a considerable network of hard surfaced roads built with their own equipment, and revegetates all dirt roads after logging. Roads are laid out on the side hill slopes away from streams and culverts are used across streams. This work appears not only justified but necessary. Baltimore's first reservoir was abandoned because of sedimentation; their second, built in 1881, lost 85 percent of its capacity within 20 years. (Baltimore has an especially difficult problem with sedimentation in Piedmont Soils.)[3] Planting of pine was begun in 1912, and today the watershed has about 2,300 acres in plantations. The City is cooperating actively with the Northeastern Forest Experiment Station in forest-water studies on three small watersheds.

Newark, New Jersey, with 36,000 acres on its Pequannock supply (one of two water sources) represents a second type of management. Here roughly 90 percent of the drainage area is owned outright by the City and sedimentation is no problem because of the type of soil and a complete forest cover. Here sales, generally held to a minimum, are conducted in a manner similar to private sales under state supervision. After inventory and determination of cut, trees are marked for cutting, the volume to be removed advertised by species and diameter, and all sales are of

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[1]Riehl, Merrill L. Considerations in recreational use of impounding reservoirs. Amer. Water Works Association 48: 1406-1408. 1956.

[2]Lull, Howard W. Forested municipal watersheds in the Northeast. Jour. Forestry 58: 83-86. 1960.

[3]Sushko, W. C. and Reigner, I. C. Management of forested watersheds for the City of Baltimore. Unpublished manuscript. Northeastern Forest Expt. Sta. 1959.

stumpage. The Administration does not look at the forest as a source of income and all sales must be justified on the basis of full maturity, fire damage, plantation thinning, or the like. The one management objective is the best raw water possible. Picnic areas, for example, are available without cost to any one, not as a recreational facility but as a means of controlling littering along the road. Newark is using herbicides for brush control and conducting cooperative watershed studies with the Northeastern Forest Experiment Station.

Hartford, Connecticut, owns about 30,000 acres of watershed forest of which the forester considers about 20,000 operable, and is cutting about one million feet a year. They, like Newark, sell units of marked, standing timber. Herbicides are used on rights-of-way and shorelines for brush control.

The New Haven Water Company, while not in municipal ownership, has been a model for municipalities for many years past. Until 1948 its 21,000 acres were administered by the Yale School of Forestry, and the compartment records are as complete as on any area of similar size in the United States. While the School continues to use the Company lands and advises on their management, it is now using University lands for most of the forestry training and management is perhaps not as intense as ten years ago. The policy, however, is still for maximum sustained yield. One change in recent years has been a marked increase in number and width of coniferous plantings along reservoirs and streams, with a width in some cases of almost a hundred yards. An experimental conversion is being undertaken in a few areas in an effort to control deposition in reservoirs of fine organic debris flushed out of narrow mucky swamps by heavy rains and quick runoff. This involves complete clearcutting of the hardwoods, spraying the sprouts with sufficient applications of ammate to exhaust the root stocks, and planting of the larger hummocks, with generally excellent survival.

Providence, Rhode Island, with 11,440 acres in forest under professional management, is giving intensive treatment to their 1,400 acres of plantations established since 1926. Ammate is the herbicide used on all brush control.

The Bethlehem Authority in Pennsylvania, with a complete management plan for their 15,000 acres, is doing cleanings, weedings and pruning under the ACP program. (In some sections ACP is not available to municipalities.) Like most municipal watersheds in Pennsylvania, they enjoy a tax-free status so long as no timber or other forest product is cut for profit. Bethlehem, with a comparatively new municipal watershed, looks on recreation and big game hunting as second to production of water. Their 25 miles of fire lanes are closed to public vehicles at all times but are accessible by foot.

Holyoke and Amherst, Massachusetts, with 5,000 and 1,800 acres respectively, are representative of some of the smaller watersheds in Massachusetts and other New England states. Each of these towns hires the same consulting forester for 20 days each year, with a modest budget for labor and equipment. Spraying of hardwood growth with 245-OS foliage spray is being done with a portable backpack mist sprayer for $10.00 to $15.00 per acre. The cut on the Amherst watershed is about 100M feet a year. On the Holyoke watershed, considerable time has been spent on revegetating with grass and forest plantations of a 60-acre spoils area below a new dam. Management plans are being prepared for both watersheds, and planting, timber stand improvement, and other general forest practices are all carried on within the limits of their budgets. These two watersheds provide a good picture of well managed, small municipal watersheds in the Northeast.

Among other large watersheds are Springfield, Massachusetts, with over 12,000 acres; North Adams, Westfield, Worcester, Massachusetts; Manchester, New Hampshire; Frederick, Maryland; Atlantic City, New Jersey; and New Britain and Waterbury, Connecticut, with between 5,000 and 6,000 acres each. Gorham, New Hampshire; Little Falls, Glens Falls, Rochester, New York, and the Rutland, Vermont, watersheds vary from 4,000 to 5,000 acres. There are many smaller watersheds between 1,000 and 4,000 acres.[4]

In Connecticut 41 of the 58 watersheds are owned by private companies, with the Bridgeport Hydraulic Company, second in size to New Haven Company, owning 17,000 acres.[4] In any of the states in which there are national or state forest holdings cities and towns benefit from their watersheds. Further, no really comprehensive survey has ever been made and it is likely that in New York State, for example, with 672 community forests, many of these may be in part or entirely for watershed protection, compared to the known list of 48 municipal watersheds.[4]

Recreation, an increasingly vital problem in the Northeast, varies to such a degree that a comprehensive picture cannot be given here. All surface supplies must be chlorinated, and sanitary engineers are almost unanimous in feeling that where fishing and swimming are permitted in raw water supplies filtration should be employed. This may easily increase treatment cost $20.00 to $30.00 per million gallons. It appears that generally water supply agencies do not favor recreational use because of the added control problems involved, and are trying to "hold the line" particularly with regard to increased use for fishing and swimming.

Summary

Many private water companies are practicing good forestry on lands they own for raw water production. The rate of area expansion has slowed, and taxes in certain areas may tend to reduce holdings in the future. While many of

[4]Lull, Op. cit.

the smaller municipalities own a large percentage of the drainage area on the larger watersheds, the tendency is to control lands along streams and reservoirs. Management varies a great deal but the trend is toward management for sustained yield and maximum income, and toward multiple use under restrictions. There is a great increase in the use of herbicides for brush control and ammate, probably the most expensive, is generally favored because of a possible deposition of phenols by the hormone compounds. There is also a trend toward increasing the number and width of coniferous plantings around reservoirs, primarily for fall hardwood leaf control. Some of the larger water companies are undertaking research on small watersheds to determine whether summer yield can be increased through some type of cover control. Increased use of practically all of the lands on eastern watersheds for travel, recreation, housing, and other purposes would seem to justify retention and even expansion of municipal holdings where practicable.

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Educational Programs in Watershed Management

Robert E. Dils

Our present population explosion coupled with ever-increasing new uses for water indicate at least a doubling of our current water requirements in the United States by 1980. Concern as to the sources of tomorrow's water is focusing mounting attention on watershed management, particularly on the wild lands of the nation which contribute well over half our total streamflow.

Much of the husbandry of our forests and wild lands is now entrusted to professional resource managers, largely foresters and range managers. Most of these men have had professional training in forest management, range management and to a lesser degree, wildlife management. In only a few cases has their training included work in the water resources field. It is a generally accepted view that forestry embraces the management not only of timber, but of all products and services of forest land including water, wildlife, forage, soil protection, and recreation. Particularly on much of our public forests and wildlands, the value of the water resource far exceeds the value of the timber and range resource.

Until recently professional training in watershed management in our colleges and universities has been available only as an elective course and at just a few institutions. Consequently, the acquisition of some degree of competence in this field for resource managers, educators, and research technicians has, of necessity, been through observation and experience, self-study, in-service training, and graduate study.

Increasing attention to the management of our forests and wild lands for water and watershed protection on both public and private land is evident. Public awareness of the importance of watershed management has been very measurably heightened through the Small Watershed Program (Public Law 566) administered by the Soil Conservation Service and in which many foresters and range managers are cooperating.

An increasing number of private and quasi-public watershed organizations are being formed each year. Many municipalities and utilities companies have or are entering into watershed management programs on lands which they own or lease. Several state conservation

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agencies now have active programs in watershed management. A number of states have authorized new civil service positions with such titles as watershed forester, watershed economist, and watershed manager. Extension specialists in soil and water conservation (cooperating with the federal Extension Service) are currently employed in many states.

In addition to resource managers with training in watershed management there is a need for trained specialists in the field to fill research, administrative and educational positions. Currently, the largest single employer of such specialists is the federal government, particularly the U. S. Forest Service. Each of the national forest regions has one or more watershed staff positions. Each of the regional forest and range experiment stations now has watershed research programs and employs from 4 to 28 technicians. Their watershed management research program has nearly doubled within the past five years.

Similarly, at least 18 of our forestry and range management schools now offer one or more courses in watershed management and many universities and agricultural experiment stations have recently added projects in watershed management to their research programs.

Thus today—and even more tomorrow—scientists, resource managers, and educators trained in the management of our water resources are and will be in great demand.

Objectives

The objectives of watershed management education are twofold. The first is to impart some basic training in watershed management to all students in wild land management programs. The second is the training of watershed management specialists.

Increasing emphasis upon the use and management of our water resource and upon the multiple use management of our forests and wild lands is inevitable. To meet this challenge it will be necessary for land managers to acquire an appreciation for all the resources of our wild lands and their interrelationships, particularly relations with the human resource. Academic preparation will necessitate either a graduate degree or a fifth year of college training, or a broadening of undergraduate programs. Despite the already crowded professional curricula of resource managers it is nonetheless extremely desirable that at least one course in watershed management be required of all resource students. If necessary, this may be at the expense of some specialized course or courses such as seeding and planting or advanced courses in mensuration, silviculture, forest management, or range management which could be given greater stress in graduate programs in forestry or range management.

Similarly, it would be very desirable to include a course in watershed management among the recommended electives for students in civil engineering, soil science, agriculture, and other related disciplines.

The second objective in watershed management education is the training of specialists—for land management, research, and education. The academic training of specialists may be accomplished to some degree through specially designed undergraduate curricula, or preferably, through graduate programs. Graduate programs are already strongly recommended or required for positions in research or teaching. They will undoubtedly be increasingly essential for men who are to become professional land managers, whatever their field of specialization may be.

Development of Watershed Management Education

Colleges and universities have responded to the need for such specialized training particularly in the past 15 years by introducing professional courses and curricula in watershed management.

The first formal course dealing largely with wildlands and water was initiated in 1932 at the University of California by Dr. Joseph Kittredge under the title "Forest Influences." In 1935 Utah State University offered the first course specifically labeled "Watershed Management." Since 1946 at least 16 additional schools offering forestry or range management have introduced courses in, or closely related to watershed management. Course titles include forest hydrology, water resource management, and watershed analysis as well as forest influences and watershed management. Today 18 of the 28 forestry schools accredited by the Society of American Foresters and at least two unaccredited forestry schools offer one or more professional courses dealing with watershed management.

Separate options in watershed management were first offered by Utah State University and Colorado State University in 1947 and 1951 respectively.

Education in watershed management really received a big boost in 1958. Recognizing the need for trained personnel in this field the Charles Lathrop Pack Forestry Foundation made grants to the Universities of Arizona and New Mexico and to Colorado State University to provide such educational opportunity. These grants permitted the establishment of a department of watershed management at the University of Arizona and a Cooperative Watershed Management Unit at Colorado State University. The grant to the University of New Mexico is being used to establish an extension type program dealing with watershed conservation.

Undergraduate Curricula

Five schools are currently offering separate undergraduate curricula in watershed management. At both the University of Arizona and Colorado State University the B.S. degree with major in watershed management is given. Montana State University offers a B.S. in Forest Conservation with specialization in watershed management. At Michigan State University, the B.S. degree in Land and Water

Conservation is available through the Department of Resource Development. The watershed management curriculum at Utah State University is offered through the Department of Range Management.

Except for the programs at Michigan State and Utah State Universities the curricula follow rather closely the recommendations of the Society of American Foresters committee on the *Training of Men in Forest Hydrology and Watershed Management* (Wilm et al., 1957). A composite of four of the curricula now offered is given in Table 1.

It is apparent that the course requirements in forestry are minimal in comparison with regular forestry curricula. Three of the four institutions include sufficient forestry courses to meet the minimum requirements for Civil Service employment as a forester and the Society of American Foresters requirements for membership. In each case, however, additional forestry courses may be elected to complete the total course requirements.

Watershed management programs actually represent a synthesis of several related disciplines. In addition to training in watershed management and other aspects of resource management, botany, civil engineering, soil science, and geology courses are required. Prerequisites imposed on some of these allied courses necessitate a reduction in forestry courses and electives that might ordinarily be required. This is particularly evident in the case of the courses in hydrology. At three of the four institutions mathematics through calculus, statics, dynamics, and fluid mechanics or hydraulics or some combination of these are prerequisite to the course in hydrology. At both Utah State University and Colorado State University the prerequisites to the hydrology course alone amount to 17-18 quarter credits, the equivalent of one full quarter of course work.

One weakness of the curricula appears to be the lack of course work in the arts and humanities. Two institutions indicated that at least 10 credits of elective work should be selected from among the following courses:

- English and literature
- Advanced communications (speech and technical writing)
- Philosophy or ethics
- History and government (including political science and public administration)
- Social science (sociology and psychology)
- Teaching methods (particularly for adult education and extension workers)

The curriculum above is quite technical and like most professional curricula in forestry and civil engineering the cultural aspects are slighted. All too often in the selection of additional coursework the student elects to take additional technical courses. The writer feels that undergraduate students should be directed to take the majority of his available electives in cultural subjects.

Graduate Programs

Programs designed to meet the needs of graduate students interested in watershed management have been arranged by a number of universities for several decades. Specific graduate programs with a major in the field of watershed management are relatively new. In cooperation with an Irrigation Institute established at Colorado State University the Master of Forestry and Master of Science degrees, each with major in watershed management, were offered for the first time in 1947. The Master of Science degree with major in watershed management was initiated at the University of Arizona in 1959.

With the assistance of the Charles Lathrop Pack Forestry Foundation Grant, a grant from the U. S. Department of Health, Education and Welfare (National Defense Education Act), and the cooperation of the U. S. Forest Service, Colorado State University launched the first doctorate program in watershed management in 1959. In recognition of the need for graduate training opportunity in watershed management, the U.S. Forest Service assigned a watershed research scientist to work with the Cooperative Watershed

Table 1.—Composite of Curricula in Watershed Management at University of Arizona, Colorado State University, Montana State University, and Utah State University[1]

Freshman	Quarters	Sophomore	Quarters
Freshman English	2	Organic Chemistry	1
General Inorganic Chemistry	3	Surveying	1
College Algebra	1	Map Drafting or Drawing	1
Trigonometry	1	Calculus	1
Analytic Geometry	1	Soil Science	1
Botany	3	General Geology	1
Speech	1	Plant Physiology	1
General Forestry	1	Dendrology	2
Military Science	3	General Economics	2
Physical Education	3	Military Science	3
Ten Week Summer Camp Following Sophomore Year			
Junior		Senior	
Statics and Dynamics	2	Plant-Soil-Water Relations	1
Hydraulics or Fluid Mechanics	1	Soil Physics	1
Forest, Plant or Range Ecology	1	Hydrology	1
Silviculture	1	Geology (Geomorphology)	1
Photogrammetry	1	Statistics	1
Physics	2	Meteorology or Climatology	1
Range Management	1	Forest or Natural Resource Economics	1
Forest Management	1	Forest Management	1
Forest Protection	1	Technical Writing	1
Forest Mensuration	1	Policy & Administration	1
Forest Utilization	1	Soil & Water Conservation	1
Watershed Management I	1	Watershed Management II	1
Elective	1	Electives	4

[1]At Utah the program is offered in the Department of Range Management. Forestry courses are replaced by courses in range management.

Management Unit to provide guidance to graduate students.

As in any field, graduate programs should be tailored to the interest and academic experience and background of the individual student. At the same time there should be a core to the program consisting of key courses in watershed management and closely allied fields. Beyond these essential courses individual graduate programs will vary considerably. Graduate schools generally require a minimum of 30 semester hours or 45 quarter hours of credit for a master's degree or approximately 60 semester hours or 90 quarter hours beyond the master's degree for the doctor's degree. Variation exists in the credit allowed for the master's thesis or the doctoral dissertation (at many institutions maxima of 15 and 35 quarter hours respectively are permitted). Graduate programs in watershed management generally require more than the minimum amount of coursework since the program is inter-disciplinary and prerequisite courses must often be included as collateral work. The majority of students entering into graduate programs in watershed management have their undergraduate degrees in forestry or range management and usually must make up deficiencies in mathematics. In addition to the coursework and dissertation most institutions require a reading knowledge of two foreign languages. In a few instances additional coursework in statistics may be substituted for one language.

A list of courses commonly included in a graduate program in watershed management is given in Table 2. This is only a partial list of appropriate coursework and does not preclude additional work in these fields or in such fields as physics, chemistry, economics, geography, and others. The asterisk indicates the courses usually considered as the core of a graduate program in watershed management. Again, the individual program will depend upon the type of degree offered, the career objective and the experience of the individual student.

Most of the forestry schools now offering graduate study in forestry and range management indicate that facilities are available for research in watershed management (Wilm, et al., 1957). Several institutions have active watershed research projects established within their agricultural experiment stations or in cooperation with federal or state conservation agencies which provide research opportunity for graduate students. The Forest Service experiment stations have been particularly helpful in working with the forestry schools in such cooperative efforts.

TABLE 2.—PARTIAL LIST OF COURSEWORK APPROPRIATE TO A GRADUATE PROGRAM IN WATERSHED MANAGEMENT

Watershed Management	*Engineering*
*Watershed Management I (Principles)	Fluid Mechanics or hydraulics
*Watershed Management II (Practices)	*Hydrology
*Watershed Analysis	Advanced Hydrology & Flood Control
Research Methods	Ground Water Development
Advanced Studies in Wildland Hydrology	Erosion and Sedimentation
*Seminar in Watershed Management	Meteorology and/or Climatology
Problem Studies in Forest Influences or Watershed Management	Irrigation Practice
	Water Quality (or Water Pollution)
Resource Management	*Soil Science & Agronomy*
Advanced Forest Management	*Forest & Range Soils and/or
Advanced Forest Ecology	*Soil Physics
Regional Silviculture	Advanced Soil Physics
*Integrated Resource Management	Soil Chemistry
Range Management	Soil Genesis and Morphology
Wildlife Management	Soil Classification & Mapping
Wildland Recreation	Soil Conservation Practices
Fisheries Science	Physical Edaphology
Graduate Seminar or Symposium	
Botany	*Mathematics*
Plant-Soil-Water Relations	Calculus
Advanced Plant Physiology	*Statistics
Advanced Plant Ecology	Analysis of Variance & Covariance
Physiological Ecology	Design of Experiments
Plant Geography	Machine Computations
Geology	*Arts and Science*
*Geomorphology or Advanced Physical Geology	*Logic, Philosophy, or Ethics
	Philosophy of Science
Ground Water Geology	Advanced Technical Writing
Sedimentation	Political Science
Glacial Geology	Public Administration
Geophysics	Rural Sociology
	Psychology
	Natural Resource Economics
	Water Law
	Urban and Regional Planning

*Courses usually considered as core courses in a graduate program in watershed management. (The reader is also referred to Wilm, H. G., et al. The training of men in forest hydrology and watershed management. Jour. Forestry 54:268-272. 1957.)

Related Programs

In addition to academic programs in watershed management offered by colleges of forestry or range management, a number of graduate programs closely allied to watershed management are available through schools or departments of geology, public administration, geography, and others. Several such programs are cited as examples.

Columbia University established graduate programs in hydrogeology leading to the M.A. or Ph.D. degree in 1958 administered by their Department of Geology. Like the programs described previously, the course program is inter-disciplinary, drawing principally from courses in geology, hydrology, hydraulics, soil mechanics, meteorology, climatology, and statistical analysis. One course in conservation is included in the program. Cooperative research between the U. S. Geological Survey and the university may be arranged in which qualified graduate students will undertake thesis research projects acceptable to the university as well as serving the

needs and direct interests of the Geological Survey.

In 1956 the Harvard Graduate School of Public Administration instituted a research and training program in water resources development. The program is financed by a grant from the Rockefeller Foundation and lists two basic objectives—research on problems of design and operation of multiple purpose systems of water resource development, and advanced training for mature employees of the several government water resource agencies. Their research program is centered around a weekly seminar in which faculty members, trainees, and expert consultants, including engineers, economists and water resource planners, examine problems of system design and operations affecting water resource development. In addition to the seminar type research studies the students or trainees fulfill the training objective of the program by attending related courses to qualify for a Master of Public Administration degree.

Summer programs related to watershed management were offered in 1957 and 1958 by the Maxwell Graduate School at Syracuse University. The theme of their 1957 Conservation Institute program was "Watersheds and You" while the 1958 session offered through their Natural Resources Institute dealt with "The Region and the Small Watershed." Graduate credit in either geography or political science was available. These programs were designed for teachers of social studies and earth sciences, graduate students in geology, forestry, ecology, economics, geography, public administration, sociology and urban and regional planning as well as professionals engaged in natural resources work.

In addition to such academic programs federal and state agencies engaged in watershed management conduct in-service training programs for their employees. Such programs may include technical classroom type sessions, field trips, assignment to research centers or forests with active watershed management programs or a combination of these. In addition, orientation courses for new employees, ranger and supervisor meetings, and research center meetings often serve as training sessions. Some of these meetings are devoted exclusively to watershed management. Additional training is avilable, too, through correspondence courses such as those offered by the U. S. Department of Agriculture Graduate School.

In recent years a number of public agencies have selected qualified personnel engaged in watershed management activities and detailed them to universities for specialized training in watershed management which was not previously available.

Summary

The current shortage of trained personnel and increasing emphasis upon the management of our water resource indicate the need for more adequate professional training in watershed management. This need includes some basic training for all resource managers and specialized training for technicians, researchers, and educators engaged in or who plan careers in watershed management.

Our universities are responding to the need for academic training in the water resource field through the addition of professional courses and the establishment of separate options or curricula in watershed management. The complexity of the water resource and the necessity of integrated resource management for watershed management make graduate study valuable particularly for researchers and educators. Graduate programs through the doctorate degree specializing in watershed management are now available. These programs are inter-disciplinary and generally involve a course program combining work in resource management, engineering, soil science, geology, social sciences, and botany, as well as in watershed management.

To keep abreast of a rapidly expanding field, conservation agencies are conducting in-service training programs and encouraging and assisting their employees to return to the universities for specialized programs and graduate study.

Watershed Research Needs and Probable Future Trends in Watershed Management

Herbert C. Storey

WATERSHED management research is that broad area of investigation aimed at determining and understanding those elements and processes that affect and control the manner in which a watershed receives and yields water; and further, to determine how these controlling elements may be maintained or modified so as to best meet man's needs as to amount, quality, and timing of water yields. Such research is intended to furnish the know-how needed for management of forest and range watersheds, to provide guides for the rehabilitation of severely deteriorated areas that constitute sources of destructive floods and sediment, to guide activities aimed at protecting the soil and water values while carrying on other uses of the land, and to guide programs intended to increase total water yields or improve the timing of yields.

Applied Research

Rehabilitation.—A well-rounded research program should be made up of both basic and applied types of studies. The character of applied research will vary dependent upon the objectives of the phase of management to which it is directed. Watershed rehabilitation research is aimed at developing methods of stabilizing slopes and streambanks, reducing silt load of streams, and in reducing peak runoff from areas that are seriously deteriorated due to past misuse. Deteriorated watersheds require special management techniques involving protection from fire, grazing, and other disturbances; reforestation or range reseeding, establishment of special soil-conserving cover crops; and such measures as mulching, fertilizing, and mechanical practices and structures. Restorative measures are often difficult and costly. Current techniques should be evaluated under a wide variety of soil and climatic conditions, but even more urgent is the need for development of new and more efficient techniques. Included in this category would be such things as studies of plant characteristics needed to control erosion on severely eroded sites, determination of optimum combinations of plant cover and structures to arrest accelerated erosion, and development of designs and methods of placement of structures to stabilize mountain stream channels.

Protection of soil and water.—On forest and range watersheds, a better understanding of the hydrologic and site productivity effects of different management practices is needed to provide the best integration of various uses with a minimum of sediment damage and interference with streamflow regimens. This will lead to development of improved methods and techniques for protecting, improving, and utilizing the various resources while maintaining stable soil, uniform runoff, and desirable watershed conditions. Particularly critical and urgent is the need for development of new timber harvesting methods for steep forest areas. Determining methods of location and construction of access roads with minimum damage to streams and slopes is a closely related problem. There is also need for development of methods of managing recreation areas to prevent extreme soil compaction and watershed damage. Studies are needed of range use intensity and management practices to minimize surface runoff, erosion, and harmful sedimentation under a variety of soil, climate, and forage conditions, with particular emphasis on high-altitude ranges.

The research program should include a major effort toward development of measures to prevent sheet, gully, and streambank erosion and consequent downstream sedimentation. It appears more practical and economic to develop and establish erosion preventive measures rather than to slight this activity and attempt restorative practices after a destructive cycle has been established. There is need for the development of improved procedures to predict the sources, amount, and rate of sediment delivery from watersheds of varying sizes in the principal physiographic and climatic regions of the country.

Improving water yields.—The demands for more water from watersheds are growing and the need to learn how to meet those demands is urgent. The limited research already done shows possibilities of higher water yields through special management of vegetation. Further research is needed to develop principles, methods, and techniques for improving the amount, rate, timing, and quality of water yielded from watersheds. The opportunities for increasing water yields under different conditions of soils, climate, topography, and plant cover cannot be adequately

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determined until more research is done, but it appears that possibilities are greatest in those areas of relatively high precipitation. However, the need for research is urgent also in the drier zones where even a small water yield increase may mean an appreciable percentage difference in total yield and would have great economic importance. Some examples of practices offering promise toward increased yield are:

1. Converting to a vegetative cover that is more efficient in its water use.
2. Reducing the density of forest or brush cover to permit more precipitation to reach the ground and to reduce the number of plants using water.
3. Cutting of forests in snowpack areas in special patterns to increase snow accumulation and control melt.
4. Influencing the drifting of snow by artificial means in high elevation areas to develop "snow reservoirs" that could supply more late-season streamflow.

Any practices intended to increase total water yields or improve the timing of water yields must also be evaluated in terms of their effect on soil stability and other uses and products of forest and range lands.

Basic Research

While applied research furnishes information as to the effectiveness of methods and techniques required to meet various management objectives, the development of methods and techniques must be based upon a thorough knowledge of the factors, elements, and processes that control or modify water movement into, through, and out of watersheds, and the stability of soils. Basic research is aimed at meeting this need. Watershed management is concerned with that portion of the hydrologic cycle from the time water is deposited on the area until it leaves the watershed through evapotranspiration, streamflow, or groundwater flow. Therefore, those processes that affect water movement and disposal in this portion of the cycle are important, and how these processes vary with different factors and how they may be modified or controlled by man must be understood.

Precipitation.—The general distribution of precipitation throughout the country is controlled primarily by the pattern of movement of air masses which are part of the world's atmospheric circulation. The overall pattern is modified, in turn, by topographic features such as mountain ranges and to a lesser extent by smaller variations in the earth's surface. As precipitation constitutes the water supply to a watershed, it is necessary to know how gross precipitation, amount, and rate are affected by various topographic factors.

Interception.—In most watersheds the first point of modification of water movement is when precipitation strikes the vegetation. Precipitation may be retained on foliage and evaporated; it may temporarily collect on leaves or needles, then drip to the ground; or it may run down stems and thus reach the soil in a concentrated area at the base of the plants. Precipitation caught in foliage and evaporated is lost to man until it appears again as precipitation. The amount intercepted depends largely upon intensity, amount, and kind of precipitation, and the density, type, and height of vegetation. A smaller proportion of a heavy rain is intercepted than of a light shower. Snow is more readily held than is rain or other precipitation. Interception differs for grass, shrubs, trees, or combinations of these. Also, whether plants are conifers or broad-leaved, evergreen or deciduous, have large or small crowns, short or long branches, rough or smooth bark, influences interception.

The importance of interception in the water balance must be established and related quantitatively to kind of vegetation cover, kind of precipitation, and amount and intensity of storms. Precipitation that does not reach the ground and is evaporated directly has little effect on water yield or streamflow. However, energy relations indicate that intercepted moisture has a direct influence on transpiration rates of vegetation and on evaporation of surface and soil moisture. These relationships need to be established and fully understood.

Infiltration and percolation.—Precipitation reaching the ground may be evaporated from the surface of the soil, it may run off the surface, or it may enter the soil to be evaporated or used by vegetation or to drain into streams, springs, or underground aquifers. The process of water entering the soil is infiltration, and the movement of water to deeper depths in the soil is percolation. Water entering the soil first replenishes moisture deficiencies and raises soil moisture to field capacity, and then contributes to streamflow or ground water storage.

Infiltration is determined by conditions at the immediate soil surface, whereas percolation is controlled by subsurface conditions. Soils having coarse texture or of large aggregates, a layer of litter and humus on the surface, insects and small animals working in the soil, and abundant roots of vegetation to make spaces for water movement and storage have high infiltration and percolation rates. Water in large pore spaces of the soil is held only temporarily, but this may be important in preventing rapid runoff of water during storm periods. Ultimately, soil water drains to lower depths or is withdrawn by evaporation, transpiration, or lateral flow. Infiltration is affected by the nature of the soil, its physical condition, and the amount and kind of litter and humus at the soil surface. Kind and amount of vegetation, use of the land, and intensity and amount of rainfall are some of the factors involved that need to be studied and interrelated. From this should come concepts of establishing different combinations of vegetation cover and soil to increase soil moisture and ground water on the one hand, or to increase the amount of runoff on the other.

Percolation, being the process of deep penetration of water into the earth's surface, is perhaps less manageable but also less understood. Information is needed as to what happens to water that goes to deeper depths; how rapidly and in what direction it moves; how much reappears at the surface or goes into deep storage; and what are the elements of soils and geology that influence this water movement.

Evaporation, transpiration, and sublimation.—The various processes and energy relations involved in water liquid-vapor-solid exchange are key elements in water movement and disposal. These processes and energy relations must be meticulously studied so that their character, interrelations, and how they vary with different elements of the landscape and atmosphere may be fully understood. The process of evaporation of water from soil and water surfaces needs to be evaluated under different conditions of climate, vegetative cover, and soil. The amount, rate, and time of transpiration by different plants under a variety of environmental conditions needs to be determined. The various factors involved in evaporation from or condensation on snow need to be determined, and the magnitude of these processes must be established in order to rate their importance in the water balance picture. Snowpack structure and metamorphism and snowmelt must be studied and their controlling factors established as a basis for snowpack management for water yields and for a better knowledge of those conditions conducive to the formation of avalanches.

Streamflow.—Information is needed as to how streamflow is affected by such watershed characteristics as size and shape, steepness of slopes and stream channels, drainage pattern, and geology. This information, together with other significant hydrologic factors, is needed as a basis for estimating streamflow from ungaged watersheds.

Erosion processes.—Another broad field of study required as part of a program of basic research is concerned with the various processes and elements causing and affecting erosion. Basically, erosion is the detachment and transportation of soil particles. Research on agricultural lands indicates that the detachability and transportability of soil particles will vary considerably depending upon various characteristics of the soil. Studies are needed on forest and range soils to determine how these basic elements of erosion vary with changes in soil physical characteristics. A knowledge of these relationships is fundamental to the determination of the inherent erodibility of different soil types.

Hydraulic studies are needed on the movement of thin layers of water across the soil surface to determine the basic laws involved and the energy relations that exist. Determinations are needed as to the relationship between elements of this type of flow and soil detachment and transport.

Erosion by water may occur in a number of different forms such as sheet, gully, shoestring, and rill. Studies are needed to determine those characteristics of soil, topography, geology, and other elements that control the type of erosion that will occur.

The process of streambank erosion needs to be given considerable study, particularly as the process is affected by such things as stream geometry, characteristics and energy relations of channel flow, type and size distribution of erodible material, and other factors that might be expected to influence this type of erosion.

Plant processes.—Another highly important general subject urgently needing a large amount of intensive study is concerned with plant processes. An examination of all aspects of watershed management will show that in most cases plants are the primary agents through which management is carried out. In the majority of situations a major part of the management process consists of the establishment, modification, or removal of plants. In spite of this important place occupied by plants, we have many serious gaps in our knowledge of plant life and processes. We need considerably more information as to the growth characteristics of various types of plants as related to various elements of their environment. We need to know more about their rate and time of growth, and volume and pattern of material both above ground and in the soil. Although an appreciable amount of work of this type has been done, practically all of it has been on tree and forage species of commercial value. Many types of plants may have considerable importance in various aspects of watershed management and yet furnish no commercial products.

The processes of water movement into the roots, through plants and into the atmosphere need much study. We need to recognize and evaluate the energy relations involved and to determine the physiological and structural characteristics that affect water movement. We need to know the difference in factors that control water movement into the leaves, down the stems into the roots as contrasted to the reverse movement.

Studies are needed concerning water use-growth relations for different types of plants as affected by such factors as climate, soil (texture, fertility, structure), and age and distribution of the plants. This is needed for many types of plants having no commercial value. Information of this type is much needed as a basis for manipulation of vegetation to increase water yields.

Plants will vary greatly in their ability to become established on unstable sites and in the effectiveness of their use in arresting erosion of different types. Considerable study is needed to determine those growth characteristics or combinations of characteristics that are most effective in controlling the different types of erosion. Information of this type is needed as one of the

basic elements to guide rehabilitation operations.

Considerable work has been done in regard to the development and testing of substances that either inhibit or stimulate plant growth. Much of this work has been carried out in connection with growing of agricultural or horticultural plants. Studies of this type should be extended to cover a large number of the types of plants encountered in forest and range watersheds. Information is needed not only on the effect of these substances on the growth of plants but also on water use-growth relations. Growth stimulators may be found that could serve toward obtaining in a short time a good cover of vegetation on rapidly eroding, severe planting sites. Growth inhibitors might be used to reduce transpiration at certain critical times of the year and thereby increase water yields when demand levels are high. Or inhibitors and stimulators may be used alternately to increase or decrease water use as water supply needs and flood control needs fluctuate.

Soil processes.—No phase of watershed management can be planned or carried out without recognizing and giving due regard to the important place that soils must occupy in the overall picture. Soils support plant growth by supplying the elements, nutrients, and moisture needed. Soils supply a reservoir for the reception of rainfall or snowmelt. Soils also furnish the material that through the erosion process becomes sediment in streams and reservoirs. Thus a thorough knowledge of a number of factors and processes pertaining to soils is basic to all phases of watershed management. Much needs to be learned about soil genesis, the processes (chemical and physical) of soil formation, under different environmental conditions, and the variation in rates at which these different processes take place.

It is known that various organisms, both micro-and macroscopic, play a part in the formation and modification of soil characteristics. But few of these organisms have even been identified, let alone the determination of their place and importance in the development and modification of various soil characteristics. Forest soils are distinctly different from soils found in other environments, and it is thought that this difference is influenced to a major degree by the soil organisms found in such environment. The effect of various management practices on soil characteristics is probably realized to a major degree through the effects that these practices have upon soil organisms; therefore a thorough knowledge of these organisms, their life cycles, food habits, and importance in formation and modification of soil characteristics is needed.

Much needs to be learned of the physical characteristics of soils that control infiltration, percolation, and moisture storage, and the energy relations and forces involved, and how these various characteristics may be altered by such things as different types of vegetation, soil amendments, and other physical, biological, and chemical methods.

Past studies have shown that soils may freeze to form several different types of structure. It has also been observed that infiltration, percolation, and soil moisture storage may be greatly affected by the type of structure produced by freezing. The type and depth of soil freezing varies greatly under different land uses and conditions, and much needs to be learned in regard to the specific factors that control the formation of different frozen soil types.

Studies of water movement in porous media have provided the basis for establishment of laws concerning the movement of water in saturated soils. But the movement of moisture in unsaturated soils, the energy relations and forces involved, are not well understood, and much intensive research must be carried on to fill this vital gap in knowledge.

Soil compaction is another process that needs much further study; we need to know better what it is and the forces and factors that cause it. We also need to know how soil compaction may be best corrected efficiently and rapidly.

Additional Information Needs

A number of basic and applied research needs have been described and briefly discussed. Three additional needs for information should be included to adequately round out the picture. First of all, we need to learn how to put together all the individual processes as they vary over a watershed and accurately synthesize the reaction of the watershed to any given set of conditions. Second, and closely related to the first need, is the need to learn how to apply results from plots and small watersheds in predicting the reaction of large watersheds. Information of this type is needed to insure reliable extension of research results and to assist in sound watershed management planning. Third, and finally, we must learn how to evaluate economically various watershed programs and practices incorporating different combinations of uses and giving due recognition to intangible as well as tangible values. We need to develop new concepts and methods of economic analysis.

Program Needed

Other articles in this issue of the Journal describe watershed research under way in various parts of the country. Present studies are concerned to some degree with a number of the needs that have been cited in this paper. An appreciable portion of the Forest Service research program is devoted to watershed management research, and in addition, some work in this field is being done by certain forestry schools and other agencies. But a considerable strengthening of the total research effort is required to provide answers needed to guide management planning and practices. Users of research findings in this field are stepping on the heels of researchers, and often must proceed with insufficient knowledge. At present, the general research effort is spread too thin in an effort to give some consideration

to a few of the most urgent problems in different parts of the country.

The research effort in this field at educational institutions should be greatly increased, particularly on studies that best fit into graduate study programs. The Forest Service research effort needs to be strengthened at all present locations with particular emphasis at some 7 or 8 key locations where strong teams of scientists, encompassing a number of biological and physical disciplines, may be organized to fully meet research needs.

In addition, and highly important, adequate facilities and specialized equipment will be needed to insure that the scientists have the most modern, effective, and efficient tools with which to carry on their work. It is recognized that advances in knowledge must come from the products of the brains of our scientists, but they should not be handicapped by not having the necessary facilities and equipment.

Looking Ahead

Research must look ahead, anticipate conditions and problems, and have the answers and needed information when required. This is the ideal situation, and with a strong research program geared to properly meet all the needs that have been described we should be able to meet this challenge; otherwise it may be a case of "too little and too late."

Any look ahead must be guided by trends and developments that are now in progress. Some of these that are pertinent to the subject of watershed management are:

1. The population of this country will continue to climb at increasing rates. All accepted projections of population are agreed upon this.

2. Forest and range land area will probably decrease moderately due to the inroads of other uses.

3. The demand for products and services of forest and range land will greatly increase. All projections of needs for wood products, water, forage, fish and wildlife, and recreational opportunity bear this out.

4. The multiple-use of such land *regardless of ownership* must inevitably increase if the many mounting needs are met.

What does this mean in terms of watershed management? First, rehabilitation of deteriorated watersheds must inevitably be quickened. We cannot afford the dubious luxury of having vast areas that produce little except destructive floods and sediment. Such areas must rapidly be brought from their present position of being a drag on our national economy to one where they may provide their fair share of contributions to national needs.

Second, most forest and range watersheds must be managed with full regard for maintaining sustained, well-regulated yields of usable water, and for protection of soil, but fully integrated with other uses of the land. Although the trend will be for water to be given a high priority in the management of these areas in most parts of the country, water yields will not be augmented by completely sacrificing other uses and products.

And third, in some relatively limited areas where water needs are sufficiently acute there will be need for material modification of other uses with the inevitable reduction in other products.

An increasing intensity of management of all forest and range land is an obvious outcome of present trends and foreseeable conditions. Only intensive management can provide the best integration of all uses and services in a manner that will maximize the combined total contribution to society's needs on a continuing basis. Such a degree of intensity of management as will be needed *can* be realized and *can only* be realized if an adequate program of research is provided to show the way.

THE MAIN entrance of the new headquarters of the Arkansas State Forestry Commission in Little Rock. The building is constructed wholly of native woods and stone.

Ovid Butler (1880-1960)

Ovid Butler, 79, of Washington, D. C., executive director emeritus of The American Forestry Association and former editor of *American Forests* magazine, died February 20.

Born July 14, 1880, in Indianapolis, Ind., Mr. Butler was graduated from Butler College (now University) in 1902 with the A.B. degree. After a brief assignment as student assistant with the U. S. Forest Service, he became a newspaper correspondent for the Indianapolis *Journal* and later the *News*.

Entering the Yale University School of Forestry in 1905, he was graduated two years later with the M.F. degree, and in 1907 was appointed forest assistant on the Boise National Forest in Idaho.

Having entered the Forest Service during an era of national forest expansion, Mr. Butler rose rapidly, becoming deputy supervisor of the Boise National Forest in 1908. In the same year he was named assistant chief of the Division of Silviculture in the Intermountain Region, at Ogden, Utah.

In 1910 he was appointed assistant district (now regional) forester at Missoula, Mont. This was the year of the terrible forest fires in the northern Rocky Mountain Region, and doubtless influenced his long crusade against uncontrolled woods burning.

During the years 1915-1916 he was in charge of a special study of lumber distribution in the United States, then returned to Forest Service administration as assistant regional forester at Albuquerque, N. Mex. In 1917 he was appointed assistant director of the Forest Products Laboratory which had been established seven years earlier at Madison, Wis.

In 1922 Mr. Butler entered on what was to become the most important assignment of his professional career, when he left the Forest Service to become forester for The American Forestry Association. His title was executive secretary during 1923-1944, and executive director from 1945 until his retirement in 1948.

A most valuable activity undertaken by the Association during Mr. Butler's first decade as executive secretary was the Southern Forestry Educational Project, a three-year program to combat woods burning. Underwritten by contributions of $150,000, the project foresters carried the message of forest protection with literature and motion pictures into all parts of the South. Among the results were increased funds and improved organizations in the states for fire prevention and control.

Following World War II, the Association under his leadership, undertook a nationwide Forest Resources Appraisal to determine the drain and growth potential of the forest resource as a result of the heavy demands of war and the ensuing peacetime economic expansion. The findings were then used as a basis for the American Forestry Congress of 1946, and the Association's subsequent *Program for American Forestry* proposed in 1953.

As editor of *American Forests* magazine for a quarter-century, he was a powerful force in conservation education. Nearly thirty years ago an article in the Journal of Forestry commented: "A new era in forestry began when Ovid Butler assumed the editorship of *American Forests*. His engaging and militant editorials in that publication have been of the highest honor to the profession, for they have always been characterized by forcefulness, sanity, and charm."

In his long career, he was the author, compiler, and editor of many publications. Two of his earliest were *Wholesale Lumber Distribution in the U. S.* and *Retail Lumber Distribution in the U. S.*, both published by the Forest Service. Others were *Rangers of the Shield, Youth Rebuilds,* and *American Conservation in Picture and Story*, the latter a profusely illustrated, popular history of the development and current status of natural resources management.

In the May 1950 issue of *American Forests* was published an article titled "The Ten Most Influential Men in American Forestry." Ovid Butler was one of the ten.

"During a period of a quarter-century, the Association under his direction took a prominent, and frequently the leading, part in every important battle for conservation," the article said. "In the promotion of federal and state legislation for adequate forest fire control, in the forefront of numerous fights to preserve the national forests and national parks from exploitation, in the enlistment of popular support for hundreds of worthy conservation causes, The American Forestry Association was the army of the right and Ovid Butler its tireless chief of staff."

A member of the Society of American Foresters since 1911 he was President during 1927-1928, and was responsible for setting up the Society's first independent office and for employing the Soci-

ety's first permanent staff member. He was elected a Fellow in 1940.

Long a member of the advisory council for the National Arboretum, he was also a member at large of the National Council, Boy Scouts of America. In 1936 he was a delegate to the second World Forestry Congress held in Budapest.

In 1952, four years after his retirement, Mr. Butler received The American Forestry Association's award for outstanding service to forestry, and in 1956 Butler University conferred on him the honorary degree Doctor of Science.

For all that he was an effective popularizer of forest science who adapted modern techniques of public relations to conservation education, Ovid Butler was personally a modest, even a retiring, man. He believed firmly in education, in its power to change traditional American habits of waste and exploitation of natural resources.

Some of the causes for which he and the Association waged battle in the early 1920's seemed almost hopeless then. It was an era of conservation movements that was still influenced by the earlier crusading zeal of Gifford Pinchot and Theodore Roosevelt. Ovid Butler was a true believer in conservation; he was an enthusiast too, but one who tempered his enthusiasm with calmness.

An article published a decade ago contained this summation of Ovid Butler's career: "As much as any man of our time, he helped make conservation a household word, and forestry a useful concept."

Let that, then, be his epitaph. What American forester can ever aspire to a greater one?

H. C.

Fifth World Forestry Congress Tours

Seattle, Washington

August 29-September 10, 1960

Seven United States tours have been arranged for the Congress. These tours are primarily for visitors to the United States from other nations. However, United States nationals attending the Congress will be permitted to register for tours, provided space is available.

There will be two pre-Congress tours and five post-Congress tours. All tours will start and terminate in cities that are major transportation centers.

Each participant will make his own travel arrangements to the starting point of the tour, and from the tour termination point to his next destination. All tours will be by chartered bus, except the Alaska tour which will be by commercial airlines. No private automobiles will be permitted to join the tours.

On most tours ladies will be welcome, but it will not be desirable to include small children. In any case, the costs shown apply to all participants; there will be no reduced rates for children.

The following brief descriptions of the tours are submitted for the preliminary information of possible participants. A detailed description of each tour is available in a specially prepared Tours Guide. This Tours Guide contains instructions about registration, together with registration forms, and directions as to where they may be sent.

Pre- and Post-Congress Tours

TOUR 1—NEW YORK STATE AND NEW ENGLAND

This will be a pre-Congress tour of 7 days' duration by bus, leaving New York City on Saturday morning, August 20, and returning to New York City on Friday afternoon, August 26. The distance is approximately 875 miles. The cost, including transportation, lodging, and meals, is estimated not to exceed $135 per person.

Travel will be through the spruce-fir and mixed hardwood forests typical of the northeastern United States. The tour will include visits to the Yale University School of Forestry; Harvard Forest; a New York State nursery producing 20 million trees annually; state reforestation projects and privately operated forests; a large pulp and paper mill; an integrated sawmill; a scenic trip through the Adirondack Forest Preserve with stops at recreational and forest protection facilities; the College of Forestry at Syracuse University; the New York State Conservation Department headquarters; and many others.

TOUR 2—WEST COAST

This will be a pre-Congress tour of 12 days' duration by bus, leaving Los Angeles, California, on Wednesday morning, August 17, and arriving in Seattle, Washington, the Congress site, on Sunday afternoon, August 28. The distance is approximately 1,200 miles. The cost, including transportation, lodging, and meals, is estimated not to exceed $225 per person.

The tour will start in Southern California where the party will observe the influence of expanding population on watershed, recreation, and fire activities. Visits will be made to experimental forests; to Yosemite National Park to see the giant sequoias; colorful San Francisco logging operations in redwood and Douglas-fir timber; large sawmills, wood processing plants, plywood factories, and pulp and paper mills. Examples of multiple-use forest management on State and Federal forests, and visits to industrial tree farms, nurseries, and research centers are scheduled.

TOUR 3—MINNESOTA, MICHIGAN, AND WISCONSIN

This will be a post-Congress tour of 6 days' duration by bus, starting in Saint Paul, Minnesota, on Monday, September 12, and terminating in Milwaukee, Wisconsin, on Saturday, September 17. The distance is approximately 800 miles. The cost, including transportation, lodging, and meals is estimated not to exceed $100 per person.

Designed to provide visitors with opportunity to observe portions of the northern forest region, characterized by jack pine, red pine, spruce, aspen, and mixed hardwood types, this tour

will feature progress in forestry by the forest products industries; by Federal, State, and County Governments; and by educational and research agencies. Visits will be made to modern tree nurseries, wood manufacturing plants, farm woodlands, fire control stations, logging operations, pulp and paper mills, and to the world-famous U. S. Forest Products Laboratory.

TOUR 4—SOUTHERN REGION

This will be a post-Congress tour of 6 days' duration by bus, leaving Memphis, Tennessee, on Monday, September 12, and arriving in New Orleans, Louisiana, on Saturday evening, September 17. The distance is approximately 750 miles. The cost, including transportation, lodging, and meals, is estimated not to exceed $125 per person.

This tour will traverse three States of the deep South, one of America's most productive forest regions, characterized by the rapid-growing southern pines and valuable hardwood types. The trip will emphasize the numerous and diversified industries dependent on the timber resource, and the forestry activities of Federal and State agencies. Visits will be made to pine and hardwood sawmills; flooring, veneer, and cooperage plants; modern pulp and paper mills; experimental forests; forest tree nurseries; state forestry headquarters; forestry schools; and intensively managed industrial forests.

TOUR 5—ROCKY MOUNTAINS

This will be a post-Congress tour of 7 days' duration by bus, leaving Spokane, Washington, on Monday morning, September 12, and terminating in Salt Lake City, Utah, on Saturday afternoon, September 17. The distance is approximately 900 miles. The cost, including transportation, lodging, and meals is estimated not to exceed $125 per person.

Among the forest types characteristic of this scenic region are ponderosa pine-larch—Douglas-fir, western white pine, and lodgepole pine. Highlights of the trip will be new developments in the control of white pine blister rust with antibiotics and in forest fire research; the operations of a large tree nursery; forest industries, including logging operations, a large sawmill, and a new pulp mill; Yellowstone National Park, America's first and one of its greatest national parks; the regional headquarters and an experiment station of the U. S. Forest Service; and an inspection of the world-famous Davis County, Utah, watershed management area.

TOUR 6—THE SOUTHWEST

This will be a post-Congress tour of 5 days' duration by bus, leaving Phoenix, Arizona, on Monday morning, September 12, and returning to Phoenix on Friday evening, September 16. The distance is approximately 750 miles. The cost, including transportation, lodging, and meals is estimated not to exceed $100 per person.

The main forest type to be visited is ponderosa pine, and the associated coniferous and hardwood species typical of the arid portions of Arizona. The tour will feature watershed management with stops at the Southwest Water Conservation Laboratory; the watershed exhibits of the Arizona-Sonora Desert Museum; the 50-year-old Fort Valley Forest Experiment Station; demonstrations of irrigation projects; research in the multiple-use management of forests showing the effect of trees and grass on water yield; a visit to a modern sawmill and logging operations; and the Grand Canyon National Park.

TOUR 7—ALASKA

This will be a post-Congress tour of 6 days' duration by commercial airlines, leaving Seattle, Washington, airport on Sunday morning, September 11, and returning to Seattle on Friday afternoon, September 16. The distance to be flown is approximately 2,000 miles. The cost, including air transportation, lodging, and meals, is estimated at $275 per person.

The tour will feature the extensive national forests of southern Alaska, characteristic of the Pacific Coast fog-belt, whose coniferous species are western hemlock, Sitka spruce, and western redcedar. Visits will be made to the great pulp mills at Ketchikan and Sitka; by boat to logging operations where huge logs are bundled for rafting; to experimental forests; and to numerous other places of interest including the capital city of Juneau.

A CANADIAN TOUR

A special tour for Congress participants has been arranged in British Columbia by a committee headed by R. G. McKee, deputy minister of the British Columbia Forest Service, Victoria, B. C.

This will be a post-Congress tour of 5 days' duration, starting in Victoria by chartered bus, on Monday, September 12, and terminating in the City of Vancouver, on Friday, September 16. The cost for meals and lodging is estimated at $12 per day. Transportation will be free.

The itinerary starts with a 3-day tour of interesting forestry places on Vancouver Island, including the Duncan Forest Nursery, picturesque Cathedral Grove, Alberni and Campbell River, several logging operations, private and public forestry projects, and forest products industries. Then the tour will proceed by ferry boat to Vancouver City, for two days of visits to the University of British Columbia, the Federal Products Laboratory, industrial forestry plants, and other places of forestry interest.

Registration for this tour may be made after the Congress opens in Seattle, up to September 3. Participants desiring additional advance information may write to Mr. McKee direct.

IN-CONGRESS TOURS

Short one-half and one-day tours are planned during the course of the Congress to nearby Mt. Rainier National Park, the Snoqualmie National Forest, private industrial forest operations, a managed municipal watershed and to forest industries (pulp, paper, lumber, and plywood). Special tours will also be arranged to other forest industrial plants for those chiefly interested in forest products and their manufacture; to a university arboretum, university forests and to public and private research centers, for education and silvicultural specialists; and to state and private nurseries and a seed company plant for those interested in forest nurseries and tree seed.

HENRY CLEPPER, *Chairman*
National Tours Committee

Notes and Observations

Engineer Scale Used as Dendrometer[1]

Accurate determination of the Girard form class for standing trees usually entails climbing the tree to a height of 17.3 feet above the ground at which point outside bark diameter as well as bark thickness are measured. Girard form class is the ratio of the inside bark diameter at the top of the first 16-foot log and the outside bark diameter at breast height. A one-foot stump and a trimming allowance of 0.3 feet bring this point of measurement to 17.3 feet above the ground.

The outside bark diameter measurement at the top of the first 16-foot log can be measured to the nearest one-tenth of an inch by means of the engineer's drafting scale with less trouble than climbing the tree and with negligible loss in accuracy. The scale is fastened to a bamboo pole at right angles by means of fine copper wire, at the required height of 17.3 feet. The scale is positioned so that the "10" scale is downward and can be viewed from below. The intercept distance on the scale is read with low-powered binoculars and converted to diameter measurement by means of the biltmore formula. Allowance for bark thickness is then made by establishing the relationship of bark thickness to diameter for the group of trees measured from data taken at breast height.

A sighting distance of twenty feet is used for smaller trees. The observer stands at a distance of 15.8 feet, on the same contour as the tree in order to attain this sighting distance. The observer's station from the tree is computed as follows: eye level of 5.0 feet subtracted from 17.3 feet = 12.3 feet; then the horizontal distance $= \sqrt{20.0^2 - 12.3^2} = 15.8$ feet.

The intercept readings are then converted to diameter (outside bark) by using the biltmore formula:[2]

$$S = \frac{D}{\sqrt{1 + \frac{D}{R}}}$$

in which S = scale distance, D = diameter, and $R = 240$ inches.

Diameter outside bark values are given according to intercept scale readings in Table 1. Correction for bark thickness should be worked out locally. A good rule of thumb, however, is that diameter inside bark is 90 percent of outside bark diameter. Thus, for average conditions, the value for diameter outside bark as given in Table 1 can be multiplied by 0.90 to give diameter inside bark.

The ordinary 12-inch engineer scale can be used for trees whose diameters at the top of the first 16-foot log are 12.3 inches or less. However, a longer scale is required, either 18 inches or 24 inches in length for larger trees. Table 1 includes diameter values up to a maximum scale reading of 23.9 inches.

HENRY A. STOEHR
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[1]Contributed by the School of Forestry and the College Experiment Station, University of Georgia, Athens.

[2]Bruce, D., and F. X. Schumacher, 1950. Forest mensuration. 3rd Ed., McGraw-Hill Publishing Co., New York.

TABLE 1.—DIAMETERS CORRESPONDING TO SCALE READINGS TAKEN AT A HEIGHT OF 17.3 FEET

Reading, inches	Reading, tenths of an inch									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Diameter, inches (outside bark)									
6	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0
7	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.1
8	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1
9	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.1	10.2
10	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2
11	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2
12	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.3
13	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.1	14.2	14.3
14	14.4	14.5	14.6	14.7	14.8	15.0	15.1	15.2	15.3	15.4
15	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4
16	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.3	17.4	17.5
17	17.6	17.7	17.8	17.9	18.0	18.2	18.3	18.4	18.5	18.6
18	18.7	18.8	18.9	19.0	19.1	19.2	19.4	19.5	19.6	19.7
19	19.8	19.9	20.0	20.1	20.2	20.4	20.5	20.6	20.7	20.8
20	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.8
21	21.9	22.0	22.1	22.2	22.4	22.5	22.6	22.7	22.8	22.9
22	23.0	23.1	23.2	23.4	23.5	23.6	23.7	23.8	23.9	24.0
23	24.1	24.2	24.3	24.4	24.6	24.7	24.8	24.9	25.0	25.1

Note: multiply the diameter values (outside bark) by 0.90 to obtain diameter inside bark.

Gibberellin Reduces Root Growth of Yellow Birch Seedlings

Since gibberellic acid has proved effective for stimulating height growth of several deciduous tree species,[1, 2] it seemed to offer possibility for practical application in producing nursery stock of slow-starting species such as yellow birch (*Betula alleghaniensis* Britton). This species often averages only 1½ to 2½ inches tall by the end of the first year. Any treatment that would stimulate growth without undesirable side effects would shorten the time needed to produce stock large enough for successful field planting.

To explore this possibility, two small exploratory tests with yellow birch were made in 1957 and 1958 at the Burlington, Vt., unit of the Northeastern Forest Experiment Station's Laconia Research Center. In both tests 1-month-old seedlings were used; the tests ran for 2 to 2½ months.

A 100-ppm (parts per million) water solution of gibberellic acid was used. This solution (equivalent to 0.01 percent by weight) was considerably weaker than the 0.125 to 1.0-percent concentrations used on hardwoods by Marth et al. and Nelson; but their experiments dealt mostly with older seedlings or with cuttings. Our tiny month-old birch seedlings seemed more like herbaceous plants at that stage; so we chose the 100-ppm concentration for our tests.

The first test was started with 46 seedlings in a nursery seedbed. Twenty-eight were shaded with burlap; 18 were unshaded. Half of each group was treated with gibberellin while the other half served as a check. At weekly intervals, seven applications were made with an eye-dropper to the tips of the treated seedlings. The dosage, increased by one drop each week, rose progressively from one to seven drops per seedling. Seventy-one days after the first application, the seedlings were harvested. All treated, unshaded seedlings had died—apparently due to desiccation[3]—so comparative results were obtained only for survivors in the shaded group.

The second test was made with 10 treated and 10 untreated seedlings growing individually in clay pots under a plastic cloth that reduced the light by 63 percent. Eight applications of gibberellin were made with an eye-dropper at weekly intervals, with progressive increases in dosage from 2 to 10 drops per seedling. Three weeks after the first application, nearly half of both treated and untreated seedlings had died.[3] The dead seedlings were replaced with untreated living ones and the treatments continued. The seedlings were harvested 61 days after the first gibberellin application. Only 4 treated and 6 untreated seedlings were still alive.

At harvest time, heights of surviving seedlings in both tests were measured to the nearest 0.1 inch. Average weights were obtained by weighing all treated or untreated roots or stems (without leaves) together and dividing by the number of seedlings. Weights were determined to the nearest 0.1 milligram (Table 1).

Both tests indicated that gibberellin greatly reduced root growth in terms of dry weight. Height growth was moderately stimulated, and stem dry weight was slightly more than for the controls. Hence, the root/stem ratio (dry weight basis) of the treated seedlings was much lower than for the controls.

Gibberellin, at least as used in these tests, obviously is not well adapted for use as a growth stimulant in the production of well-balanced yellow birch nursery stock. Although the tests were of very limited scope, it seems doubtful, in view of the adverse effect of gibberellin on root growth, that other concentrations or methods of application would be better adapted to the purpose.

WILLIAM B. LEAK
Research Center, Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Laconia, N. H.

[1]Marth, P. C., W. V. Audia, and J. W. Mitchell. Effects of gibberellic acid on growth and development of plants of various genera and species. Bot. Gaz. 118:106-111. 1956.

[2]Nelson, T. C. Early responses of some southern tree species to gibberellic acid. Jour. Forestry 55:518-520. 1957.

[3]These losses occurred despite inspection of the plants every 2 or 3 days and watering when need was evident.

TABLE 1.—AVERAGE HEIGHTS AND WEIGHTS OF YELLOW BIRCH SEEDLINGS TESTED WITH 100 PPM GIBBERELLIN ACID

Test	Seedlings used	Average height	Average ovendry weight[1]			Root/stem ratio
			Stem	Root	Total	
No. 1:	*Number*	*Inches*	*Milligrams*	*Milligrams*	*Milligrams*	
Treated	12	1.7	5.0	3.8	8.8	0.76
Untreated	13	.7**	4.2	10.0	14.2	2.38
No. 2:						
Treated	4	2.4	5.1	5.0	10.1	.98
Untreated	6	.7*	3.2	13.0	16.2	4.06

*Significant at 5-percent level.
**Significant at 1-percent level.
[1]These data are lumped averages that did not admit of statistical analysis.

Plots Demonstrate 16 Years' Loss from Littleleaf

Estimates of the loss from littleleaf disease were made for 18 counties of the South Carolina Piedmont in 1950 (*4*). No data, however, have been available for evaluating the loss from the disease on specific areas over a number of years. The present paper reports the progress of the disease on 27 plots established in 1940-1941 and followed closely for 16 years. Earlier reports (*5, 6*) were published after 5 and 10 years of observation.

During 1940-1941, T. S. Buchanan[1] established thirty-four 0.4-acre plots in the littleleaf belt to study cumulative losses under different degrees of initial severity. The plots were located in representative shortleaf pine stands from western Alabama to central Virginia. Since establishment, 7 of the plots were rendered useless for further study because of cutting, severe fire, or other causes. Ten of the plots remaining in the study were in Alabama, 5 in Georgia, 6 in South Carolina, 1 in North Carolina, and 5 in Virginia. When established, some of the plots were apparently healthy, others were moderately diseased, and a third group was severely diseased.

Table 1 shows the progress of the disease on the 27 plots remaining in the study after 16 years. The table presents loss data separately for those plots that were healthy, moderately diseased, and severely diseased in 1941. The figures are based only on the dominant and codominant shortleaf pines that were unmolested throughout the study. Trees that were windthrown, killed by insects, or died of other causes are not included.

[1]Formerly pathologist with the Bureau of Plant Industry, Soils, and Agricultural Engineering, and now assistant director, Division of Forest Disease Research, U. S. Forest Service.

TABLE 1.—PROGRESS OF LITTLELEAF ON SHORTLEAF PINE DURING 16 YEARS OF OBSERVATIONS

Plot no.	Average age, 1941	Dominant or codominant shortleaf pine, 1941	Trees diseased, 1941	Trees dead, 1957	Trees dead or diseased, 1957
	Years	*Number*	*Percent*	*Percent*	*Percent*
	HEALTHY (0-5 PERCENT DISEASED IN 1941)				
9	51	5	0	20	60
14	25	17	0	94	100
17	42	27	4	0	7
20	40	9	0	11	78
23	62	42	0	10	21
28	50	31	0	0	10
30	24	48	2	25	46
31	47	57	0	9	35
33	34	81	1	48	89
	41	317	1	25	49
	MODERATE LITTLELEAF (6 TO 20 PERCENT DISEASED IN 1941)				
3	33	15	13	80	100
6	35	12	17	50	92
11	21	24	8	33	83
16	34	17	12	41	76
21	37	35	20	49	97
24	27	78	15	26	87
29	27	61	10	8	43
32	39	105	10	30	85
35	67	41	10	17	37
	36	388	12	29	75
	SEVERE LITTLELEAF (21 PERCENT AND OVER DISEASED IN 1941)				
1	41	8	75	38	100
2	28	40	23	35	80
5	51	27	30	56	85
8	53	18	44	17	78
10	35	47	43	81	89
12	39	32	25	84	97
13	34	30	27	53	70
15	32	38	24	89	100
22	30	45	42	62	78
	36	285	33	62	86

Of the 9 plots that were essentially healthy in 1941 (1 percent diseased), 25 percent of the dominant and codominant trees were dead from littleleaf in 1957, and an additional 24 percent were diseased.[2] For the moderately diseased plots (12 percent diseased), 29 percent of the trees were dead in 1957 and an additional 46 percent were diseased. For the plots severely diseased in 1941 (33 percent diseased), 62 percent of the trees were dead in 1957 and an additional 24 percent were diseased.

At the time of their establishment in 1941, the plots had a total of 990 dominant and codominant shortleaf pines, of which 15 percent were diseased. Sixteen years later, in 1957, 37 percent of the trees were dead and an additional 33 percent were diseased, leaving only 30 percent of the original dominant and codominant shortleaf pines still healthy. On plots in which 6 or more percent of the trees were diseased in 1941, the mean mortality loss in 16 years was 43 percent.

In 1941, the average age of the trees on the 27 plots was 37 years. Despite this relatively young age, almost all plots have deteriorated rapidly since establishment. Following the same system of classification used for the plots in 1941, none would be considered healthy in 1957, and only 2 would fall in the moderately diseased class. In other words, 25 of the 27 plots would fall in the severely diseased category. Wide variation in rate of deterioration among stands has been shown to be related to differences in soil characteristics (*1, 2*).

The high losses from littleleaf reported herein make it clear that in managing shortleaf pine in littleleaf areas one should consider short rotations in most stands (*3*). Forest managers should be aware of those stands where littleleaf occurs, and should keep shortleaf pine stands located within the

[2]All percents are weighted averages.

littleleaf belt under surveillance, as a stand of littleleaf age (20 years or more old) may become diseased and deteriorate rapidly.

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Pruning of Slash and Loblolly Pine Grafts

Over the past four years, slash and loblolly pine grafts have been watched closely in the seed orchards of the Cooperative Forest Genetics Research Program of the University of Florida. Most of the older grafts have grown well, and a keen eye is required to observe the graft union. However, on some grafts, the stock overgrows the scion with a characteristic "flattened milk-bottle shape" (Fig. 1). Nearly all grafts with this overgrowth have died a year or so after field planting.

At first, stock-scion incompatibility was suspected of causing the failure of these plants. However, subsequent investigation showed that there was a high correlation between the absence of healthy branches on the stock and the development of the overgrowth and mortality of the stock (and hence of the scion). Evidently there is a phloem block induced as a result of the grafting operation. Whenever there was an adequate supply of food to the stock from its own branches, the stock growth was able to match the growth of the scion and a healthy plant resulted. Sax[1,2] reviews the effects and nature of phloem blocks, and has demonstrated that downward food transport is interrupted until normal phloem growth is restablished.

These observations indicate that some healthy branches should be left on slash and loblolly pine understocks until the graft-union has completely healed. During the first year pruning should be designed to force the development of the scion, and to avoid ring knots, but some feeder branches should be left on the stock. These feeder branches can be removed after the first or second growing season in the field.

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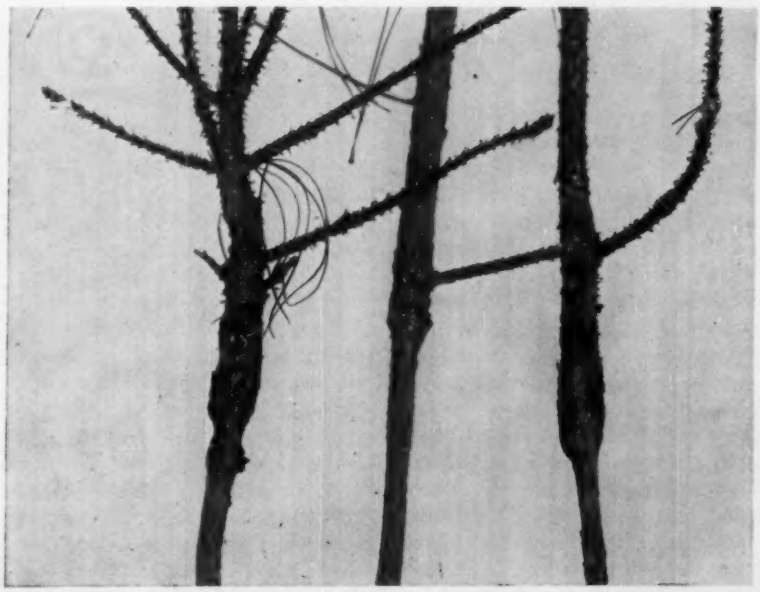

Fig. 1.—Unsuccessful graft unions. These unsuccessful grafts illustrate the flattened milk bottle shape that ensues when there are no nurse branches on the stock during the period required for reorientation of the phloem.

[1]Sax, K. Control of tree growth by phloem blocks. Journal of the Arnold Arboretum 35:251-258. 1954.

[2]————. The control of vegetative growth and the induction of early fruiting of apple trees. Proceedings of the American Society of Horticultural Science 69:68-74. 1957.

Mineral Spirits Effective in Hardwood Control[1]

Mineral spirits, a petroleum derivative with aromatic components, marketed as Stoddard Solvent, has been used successfully in nursery weed control for a number of years. A test to determine its silvicidal qualifications for the elimination of various hardwood species in the Georgia Piedmont was initiated in the summer of 1955 in the course of screening a group of potential silvicides.

The liquid material was applied in frills during the summer and winter of 1955 and 1956, at rates of one-half tablespoon (¼-ounce) and one tablespoon (½-ounce) per four inches of circumference. Frills were made by overlapping axe cuts through the bark and into the wood at the tree base, approximately one foot above ground level. Trees were treated as found in the forest, resulting in numerous species with diameter classes ranging from 1 to 12 inches d.b.h.

Observations made in the summer of 1958 after three growing seasons revealed 93 percent of the trees topkilled of which 16 percent showed no basal sprouting. Tallies of 2-year-old treatments established in the winter and summer of 1956, although not as reliable in evaluating effectiveness, indicate summer applications produce slightly better topkill and less sprouting than does winter treatment. The higher dosage rates effected superior topkill and less sprouting during both seasons. Sweetgum was noticeably resistant to topkill in contrast to other species. However, differences in kill without sprouting among species were not so consistent (Fig. 1).

Although basal sprouting was excessive, the low cost of this compound (23¢ per gallon in 55-gallon drums) seems to provide many possibilities for future utilization. For example, in stands of sapling or pole-size pines suppressed by hardwoods, release from the overstory competition for light could be accomplished without regard to basal sprouting. It should be recognized that the financial advantage indicated by the cost of mineral spirits may be lost when commercial silvicides with water carriers are effective at low concentrations.

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[1]Contribution of the Forest Physiology Laboratory, cooperatively supported by the Georgia Forest Research Council, the Georgia Forestry Commission and the College of Agriculture Experiment Station.

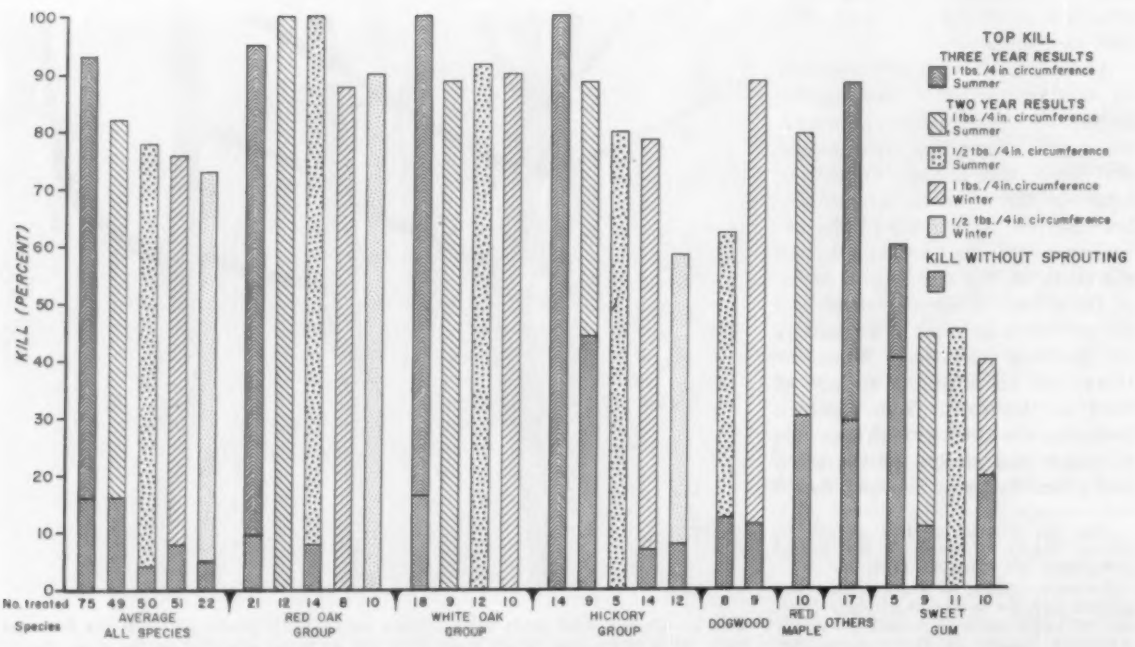

FIG. 1.—Effect of mineral spirits on several hardwood species when applied during two seasons and at two rates.

Points of View

Comments on "Color Standardization for Foliage Description in Forestry"[1]

In the January, 1960, issue of the JOURNAL, Dr. L. S. Hamilton, in an article entitled "Color Standardization for Foliage Description in Forestry" makes a clear case for the need for suitable criteria and uniformity in describing colors of tree foliage.

Dr. Hamilton quite clearly describes the difficulties involved in using ordinary descriptive terms to adequately describe the rather elusive and fine color differences which occur naturally in plant tissues. He also mentions the interest of certain tree farmers like the Christmas Tree Growers Associations in getting a better and more reliable expression for the color differences which they are observing and which are so important in the economics of their business.

However, I cannot agree yet with Dr. Hamilton's recommendation for the acceptance of the Munsell Color Charts as a useful and reliable set of standards to be used by foresters, tree physiologists, Christmas tree farmers, and others who are interested in accurately describing color. Shortly after these charts became available, S. A. Wilde and G. K. Voigt published "Determination of Color of Nursery Stock Foliage by Means of Munsell Color Charts."[2] They also published in *Agronomy Journal* 44:499-500, 1952, a similar article entitled "The Determination of Color of Plant Tissues by the Use of Standard Charts." These authors, like Dr. Hamilton, made a case for the need for such a standardization and even went farther than the recent article by Hamilton in actually designating certain specific Munsell color notations for color abnormalities found in tree and crop samples in normal condition and affected with certain nutrient symptoms. In Professor Hamilton's article, there is no reference to these two previous papers.

All of these workers, including Dr. Hamilton, have failed, in my mind, in the area where they could have made a real contribution. Where is a detailed, statistically valid reporting of the results of a series of controlled tests in which the suitability and reliability of these charts for accurately describing color differences in plant tissue by independent observers is either substantiated or refuted?

A number of years ago, I tried such a test with several groups of forestry students, and the results were not too encouraging. The charts work quite well when you have a fairly uniform color, or at least with minor differences masked by the general matrix, as you have in a soil sample from a specific soil horizon (soil scientists have accepted these charts for official soil descriptions). When you try to describe the color of a particular leaf of a plant or a bundle of needles, you discover, if you work with it carefully, that there is a wide range in color which ranges widely through the set of Munsell Color Charts, from the tip of the needle to the base, and from the margin of the leaf to the petiole.

I will admit that with healthy broad-leaved tree leaves usually you can get a fairly accurate and independently reproducible value for the color of the leaf blade. With coniferous needles, this is not quite so simple, but if you take a bundle of healthy needles and compare the color chips with the midsection of the needle, you can also come up with a reliable and independently reproducible value. However, this is neither the need nor the difficulty. We are concerned more with abnormalities resulting from soil deficiencies or reaction to toxic agents, such as herbicides, or effects of diseases or insects, etc. In these instances, we have internal discoloration, various tipping effects, margin effects, and there is not one color, but a range of colors. How, then, can one describe an overall tree color?

I agree with Dr. Hamilton that there is a need for a system of color standardization in forestry, but before the profession can be asked to adopt any system, the reliability and practical workability of such a system should be adequately demonstrated by research.

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[1]Hamilton, L. S. Color standardization for foliage description in forestry. Jour. Forestry 58:23-25. 1960.

[2]Jour. Forestry 50:622-623. 1952.

Licensing of Foresters

Apparently there are two purposes that the sponsors of licensing have in mind: (1) to protect the public from incompetence, and foresters from competition of nonforesters doing forestry work, and (2) to enhance the "professional" standing of graduate foresters.

If licensing is considered desirable to protect the public, presumably there must exist some danger or abuses that are expected to be reduced or eliminated by licensing. It is not clear what these abuses are, nor are examples given of such abuses. The same holds for relations with graduate foresters.

The examinations described under the Georgia plan are directed

toward techniques of forestry; in other words, candidates would be tested on their ability as technicians. There are many precedents for licensing technicians such as barbers, plumbers, and arborists. It is easier to examine technicians than to evaluate the qualities that set apart members of a profession. Licensing, if limited to examinations of competence as technicians, does not per se make people so registered a professional group.

What makes a profession? This has been discussed in these pages many times. The code of ethics is supposed to define the standards of the forestry profession. Can licensing include this? Length of training required has something to do with it. Doctors, lawyers, clergymen, architects and some engineers devote eight to ten years to professional studies. Professional men should continue to study during all their active careers, but technicians should also keep abreast of new developments.

Is not part of the confusion due to the fact that too many foresters do subprofessional work? What may be needed are more forestry technicians, graduates of ranger schools, who might well be licensed. In countries where the forestry profession is older, there are more trained men in this category. Doctors and lawyers, for instance, do not do subprofessional work to the same extent. Moreover, no one expects a law clerk or court stenographer to be admitted to the bar without professional study and a law degree, nor a laboratory technician to become an M.D. solely by dint of long experience. The recent editorial by Henry Schmitz points out the possibility of subprofessionally trained personnel as a solution to part of the problem.

Most graduates of forestry schools today look toward reasonably well paid jobs in industry or public service organizations. Their training fits them for a job and they think of their career as a job. This, I believe, tends to dilute their sense of belonging to a professional group. Early foresters in this country from 1900 to 1905 and for sometime after were fired by a crusading spirit for a great cause. We need more of this today rather than seeking protection in licensing.

HENRY I. BALDWIN
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Comments on "The Canadian Spruce Forest"[1]

In a paper entitled "The Canadian Spruce Forest" Wright has compared it with the Southern United States pine forest. The spruce forest extends from Newfoundland to the Yukon for a distance of 3,000 miles. In area it is about 250 million acres. Nearly 60 percent of the spruce is mature or overmature. The total volume of growing stock is five times as great as the volume of the southern (U. S.) pines.

Although little intensive silviculture had been practiced, empirical spruce yield tables provide some guidance—for example at Aleza Lake in central British Columbia, the yield is 90 cubic feet per acre per year, which is of course a maximum but indicates what can be achieved under intensive management of the best sites. Wright feels that 35 to 40 cubic feet (per acre per year) are attainable over wide areas in the interior of British Columbia. (Having known this area myself for 22 years, I agree with him.) On the basis of 30 cubic feet per acre per year, the ultimate yield of the Canadian spruce forest would be 7½ billion cubic feet per year, an increase of 350 percent over the present rate of cut.

Wright's cure for the problem of undercutting is to bring areas presently occupied by the forest industry up to their best level of production, because, as he says, "each dollar of investment will yield the best returns in the most favored regions where existing plants and communities are established." (Example: Vancouver District.)

In conclusion, Wright cites three steps that should be taken: (1) Accelerate the harvesting of mature and overmature forests; (2) Intensify protection efforts; (3) Aim toward complete restocking and full production on every acre. And he adds: "It is quite likely that the Canadian spruce forests will some day overtake the southern pine forests." This is a challenge to American foresters not only in the South, but also in our own spruce region, where we too have a vast potential production.

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[1]Address by Thomas G. Wright, chief forester, Canadian Forest Products, Ltd. at annual meeting of the Canadian Institute of Forestry, Prince George, B. C., October 9, 1959.

Book Reviews

A California Flora

By Philip A. Munz and David D. Keck. 1681 pp. 134 illus. University of California Press, Berkeley 4. 1959. $11.50.

Any compilation of the plants of a region that brings one up to date on new knowledge is welcome. The Munz-Keck *Flora* does this. However, to one accustomed to the classifications and nomenclature he learned earlier, such a new book is like trying to replace an old and trusted friend with one who speaks a strange language.

The Munz-Keck book, as one might expect for a region the size and variety of California—100,000,000 acres—is mastodonic. Also, one can expect that a new flora would be different from its predecessors. It is more accurately a manual rather than what the term flora, when applied to a book, generally connotes.

It describes more species than heretofore described. New data on distribution, changed nomenclature (that of the International Botanical Congress appears to be used throughout, despite its name-changing on flimsy grounds), and other systematic factors are included. The concepts of species are the authors' own.

The first important change one notes is the order of presentation, which is based on new concepts of phylogeny. The old and inclusive Pteridophyta division, or subkingdom, is broken down into Lepidophyta (club mosses), Calamophyta (horsetails), and Pterophyta (ferns), and these divisions are presented in that order, followed by Coniferophyta (conifers) and Anthophyta (angiosperms). In the latter the dicotoledons precede the monocotyledons. One accustomed to the older sequence will have to use the excellent index more freely and, if he is interested in name derivations, he will have to refer to other books.

This is the first flora published in more than 30 years, although two others, Abram's and Jepson's, both more of the style of a flora and published in part, are nearing completion of the final volumes, the late Dr. Jepson's being completed by Dr. Rimo Bacigalupi.

A comparison with Jepson's *Manual* of 1925 is inevitable. Willis Linn Jepson (1867-1946) was California's greatest pioneer botanist and, though he had not the facilities of present-day botanists nor the benefit of the critical analyses of families and genera that have been since produced by specialists, he laid a sound groundwork and high standard through his wide travels afoot, by mule or horse team and later by automobile, and through his scholarly writing and meticulous field work. Since his time, new species have been found, more has been learned about those already known, new concepts of classification have appeared, the results of chromosome numbers have become available, etc. Thus, a flora, or a manual, always a difficult, painstaking time-consuming job, is never long up to date.

Jepson describes distributions in general terms and site factors; Munz and Keck give them by plant communities of which they recognize 29. This is an improvement and gives the book's user a general picture of the habitat and social structure. Jepson gives the derivation of plant names down to species; Munz and Keck only to genera. Jepson sticks to the English system of measurements; Munz and Keck use the metric system for dimensions for plants and their parts, but use feet for elevations.

Jepson's *Manual* of 1,238 pages includes 1,023 illustrations, all beautifully drawn and with the natural grace of plants. Munz and Keck include only 134 and these are rather stiff by comparison. This paucity of illustrations is a serious loss to the lay botanist who is not as adept at applying technical word descriptions as the more thoroughly trained specialist.

Munz and Keck availed themselves of the work of specialists; thus the 4-page key to *Eriogonum* follows the work of Susan G. Stokes; the 3-page key to *Arabis* follows the monograph on the genus by R. C. Rollins; that of *Cupressus*, the study of C. B. Wolfe; etc.

Both the present authors are distinguished botanists, and both long residents and students of the flora of California. Munz is professor of botany at Claremont Graduate School and director of Rancho Santa Ana Botanical Garden, while Keck, after many years in California, is now assistant director and head curator of the New York Botanical Garden.

Foresters who may be interested in the flora of California beyond the trees should find this new book helpful though not too easy to use. For the trees they will find the descriptions not always in full agreement with their own field observations, nor will they accept some of the common names, and the uses cited for the woods. The reviewer, with several copies of Jepson's *Manual* conveniently placed, will not give up referring to it. At the same time he will not fail to use Munz and Keck's book concurrently.

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The Perpetual Forest

By W. B. Collins. 288 pp. J. B. Lippincott Co., Philadelphia, Pa. 1959. $4.50.

A Welshman, who obtained his degree in forestry at Oxford, W. B. Collins in 1938 was posted to the Gold Coast of Africa, now Ghana, as assistant conservator of forests. At the time this book was published he had advanced to deputy chief conservator.

During the 20 years that he lived and worked in the tropical forests, he was a fascinated observer of the community of plant and animal life that characterizes such areas. The title of the book derives from the endless cycle of death and life's renewal of all things from the most primitive, microscopic fungus to the tallest trees.

There is much in this delightful book about the incredibly rich fauna of the West African forest as viewed by one who is primarily a natural scientist, and only occasionally a hunter. He recounts his day-to-day experiences, while making his marches through the dark woods or while marking timber, in an easy, almost conversational style of writing. It is simple and clear, utterly without flourishes. Even his several adventures, while startling enough, are told not to emphasize danger or to shock the reader, but rather to emphasize his description of a place or event.

He encountered leopards, but driver ants were more to be feared. Cobras and gaboon vipers were to be carefully watched for, but the black ponerive ant, a venomous carnivore, had to be absolutely avoided. The hunting habits of the big forest centipede and the imperial scorpion are described with the true naturalist's understanding.

In Ghana, as in many other nations, the closed forest is shrinking. As land is needed for agriculture and urbanization the trees are forced back. Sawmills have been steadily moving in since World War II, but it is not the timber man who is destroying the forests, though he may exploit them. It is "a population swiftly expanding needing more land."

Any American forester curious about the professional career and workaday life of a West African tropical forester will find a wealth of interesting information and woodland lore in *The Perpetual Forest*.

HENRY CLEPPER

Dictionary of Economic Plants

By J. C. Th. Uphof. 400 pp. Hafner Publishing Co., New York. 1959. $9.75.

The author has prepared a highly compressed and very useful manual of economic plants giving common names, scientific names including synonyms, family names, geographic distribution, products, and principal uses. In addition to the customary inclusions, plants of local value, of ethnological interest, and those useful to primitive peoples, are also covered. Over 6,000 species are considered, arranged alphabetically, and thoroughly cross-indexed.

Those wishing more complete information will find a bibliography of over 500 titles, divided according to products, geographic treatments, and historical value, an excellent guide.

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Taxonomy of Flowering Plants

By C. L. Porter. 452 pp. Illus. W. H. Freeman and Company, San Francisco, Calif. 1950. $6.75.

Any new textbook must be evaluated not only for its classroom merit but also for the practicality of its use without benefit of an instructor's interpretation. This book is intended for one or two semester courses, primarily for students in applied biology—agronomy, conservation, wildlife and forestry. However, it is also well adapted for individual study by anyone with introductory knowledge of botany. The book avoids the pitfalls of some frequently-used texts. Many present so much detail their usefulness to beginning students is limited, and they serve best as reference books. Others oversimplify the field and therefore cannot be used without an instructor's amplification. Porter's text has found a satisfactory middle ground. In addition, he has made his subject matter a more discrete unit by omitting treatment of ferns, fern allies, and gymnosperms frequently found in taxonomy texts. This obviates a large section of evolutionary relationships, family descriptions, and terminology.

The author is professor of botany, University of Wyoming, and curator of the Rocky Mountain Herbarium. His teaching experience and work with western, arctic, and alpine plants have contributed to the production of an adaptable book.

The first section deals with the history, principles, and methods of taxonomy. The chapter on history is a concise discussion of the work of individual scholars, from Theophrastus to Eames and I. W. Bailey. A chapter on taxonomic literature explains the use of manuals, floras, indices, and catalogs, and gives a useful list of floras for various portions of the United States and Mexico. The chapter dealing with field and herbarium methods is concise, useful, and up-to-date. Chapters on nomenclature, concepts of classification, and construction and use of keys are also included.

The chapter on terminology is clearly presented and well illustrated with line drawings. It should be useful to anyone beginning the use of taxonomic keys and descriptions. Index or glossary references to the pages of these descriptions and drawings would have increased the usefulness of this section. Some terms used to describe types of inflorescence, although correct, are not frequently encountered in manuals and may be confusing to the nov-

ice. With every chapter, a list of references, including recent works, is given.

The two final sections treat the taxonomy of Angiosperms, arranged according to Engler and Prantl. Keys to families, family descriptions, drawings, and floral diagrams are included. Helpful charts comparing characteristics of related families are also given. The numerous photographs are well chosen to illustrate particular points and family characteristics. Although many of them are of western plants, their use does not limit the usefulness of the book in other regions. These sections are admirably suited to teaching the quick recognition of families in the field, an ability lacking among many college-trained biologists today.

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Duluth, Minn.

Trees, Shrubs and Vines

By Arthur T. Viertel. No page numbers. Illus. Extension Division, State University College of Forestry at Syracuse, New York. 1959. $1.25.

Designed mainly for the nonbotanist, *Trees, Shrubs and Vines* is a unique pictorial guide to the identification of almost 600 native and introduced, broadleaved woody plants usually hardy throughout the northeastern United States. Leaf drawings from fresh specimens of plants having foliage similarity, regardless of genera, are arranged in juxtaposition for direct comparison. More often than not these are supplemented with sketches representative of helpful twig, fruit or flower features. They are individually numbered and grouped according to leaf structure (simple or compound), arrangement (alternate or opposite), and margins (entire, lobed, or toothed). There are nine such groups covering 593 ornamental species and varieties.

Following its 80 pages of concise, neatly done illustrations is a complementary section devoted to plant descriptions, giving typical features of the leaves, flowers, twigs and fruit, along with useful notes on leaf persistence, maximum height, geographic range, and approximate hardiness. Those plant descriptions are also numbered in the same sequence as the foregoing illustrations. If identification of a plant is uncertain from the illustrations, final determination then depends on the specific characteristics.

Dr. Viertel frankly states in the introduction: "No method of identification will separate closely related species of difficult genera easily." Fortunately, though, the more difficult genera make up the minority. The user of *Trees, Shrubs and Vines* should avoid the usual pitfalls prevalent in previously devised systems for identification.

Other good features of this very helpful manual include its zonal map (frontispiece) adapted from the 1941 Yearbook of Agriculture —*Climate and Man;* its simple plant-group key preceding the pictorial and descriptive parts; literature citations on the subject of dendrology; two-page chart on leaf arrangements and shapes, also flower and twig details; glossary of botanical terms used; and complete index of woody plant names.

Scientific names concur with Rehder's *Manual of Cultivated Trees and Shrubs;* the common with Kelsey and Dayton's *Standardized Plant Names.* Family names come in, too, as stated "for the general interest of the reader."

Page numbers are absent due to Dr. Viertel's special way of grouping the different plants described. Instead, the pages of illustrations bear caption headings like "opposite, compound;" or "alternate, simple, lobed;" etc. serving thus as a specialized form of index. The index itself gives the plant numbers but not page numbers.

Technically designated as Bulletin 43, this 7¼ × 10" paper-backed booklet has approximately 270 pages. It is printed on excellent quality paper, is well organized, attractively bound, and meticulously edited and proofread.

Author Viertel, associated since 1946 with the Department of Landscape Architecture of the State University College of Forestry at Syracuse, has contributed in *Trees, Shrubs and Vines* an original, outstanding and withal inexpensive woody plant identification manual. The reviewer commends it not only to gardeners, horticulturists, nurserymen, landscape architects and amateur naturalists, but especially to forestry students and even to practicing foresters. Actually, it transforms dendrology from the status of a chore into one of pleasure.

John Aughanbaugh
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Publications of Interest

A career guidance brochure, entitled *What You Should Know About Career Opportunities Offered by the Pulp and Paper Industry,* has just been issued by the Technical Association of the Pulp and Paper Industry (TAPPI).

The brochure is aimed at students and technical graduates in science and engineering and related fields. It outlines career opportunities in this, the country's ninth largest manufacturing industry.

The brochure highlights several of the many facets of the technical work by pulp and paper companies and allied organizations. This is accomplished with a number of definitive articles prepared by industry leaders, government agencies, major paper producers, and other organizations directly and indirectly concerned with research and uses of paper and paper products.

The booklet also presents a background history of the industry and its growth, a projection of future potential, and a detailed analysis of the specific types of career opportunities open to graduates with science and engineering degrees.

The brochure is a 36-page, three-color production, using both artwork and photography. It is available upon written request from the Technical Association of the Pulp and Paper Industry, 360 Lexington Avenue, New York 17, N. Y.

Current Literature

Compiled by LOIS MCALLISTER, *Assistant Librarian, State University College of Forestry at Syracuse University*
Range Management Section Compiled by NELLIE G. LARSON, *Library, U. S. Department of Agriculture*

General

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The Forest Ranger: a Study in Administrative Behavior. By Herbert Kaufman. 275 pp. Tables. Johns Hopkins Press, Baltimore 18, Md. (Published for Resources for the Future, Inc.) 1960. $5.

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A Method Whereby Both the Optimum Species of Trees and the Optimum Cutting Ages Can Be Determined Simultaneously. By Takuro Kishine. 13 pp. Tables. Kyoto Univ., College of Agric., Kyoto, Japan. 1958. Memoir No. 79, Suppl. No. 1.

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Society Affairs

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Coming Events

Southern California Section

The Southern California Section will hold its meeting in San Bernardino, April 1-2, 1960.

Southwestern Section

There will be a meeting of the Southwestern Section at Tucson, Ariz., April 15-16, 1960.

Seventh National Watershed Congress

The Seventh National Watershed Congress will be held at the Statler-Hilton Hotel, Washington, D. C., April 18-20, 1960.

Columbia River Section

The annual meeting of the Columbia River Section will be held at the Umpqua Hotel, Roseburg, Ore., April 22-23. The theme of the meeting is "Forestry Today and Tomorrow" covering "Foresters and Economics" and "Professional Responsibility."

Puget Sound Section

The Puget Sound Section will hold its meeting at Port Angeles, Wash., May 13-14, 1960.

Ozark Section

The summer meeting of the Ozark Section will be held at Salem, Mo., June 2-4, 1960. Float trips on Current and Jacks Fork Rivers are planned for June 2; field trips on June 3; and dedication of Licking Nursery as George O. White Forest Tree Nursery on June 4.

Kentucky-Tennessee Section

The summer meeting of the Kentucky-Tennessee Section will be held at the La Citadelle Motel, Hazard, Ky., June 10-11, 1960. A field trip is planned on June 10 to the University of Kentucky's Robinson Forest.

Council's Column

Toward A Better Profession

Our past president, George Garratt, has already done so, but a good thing cannot be pointed out too often: Read Henry Vaux's article in the October, 1959 issue of the JOURNAL entitled "Advantages and Functions of a Professional Society." He states: "The nonprofessional has customers—the customer is always right; in contrast the professional has clients and the client regards the professional as speaking with authority to the client's conditions."

Doesn't this truly hit home?

How many of us have not accepted a highgrading—perhaps we even did the marking ourselves—because the "customer" wanted it that way? We knew the production would suffer. The stand would probably yield another cut in due time, but for every cut of that kind production would go downhill in quality, and perhaps also in quantity.

By highgrading the owner did get more money immediately, but less money in the long run. The community and the society suffered because the burden is put on future generations.

By our condoning of this highgrading or, perhaps just by not saying anything about it, the neighboring woodsowners take such practices as being perfectly proper and do likewise themselves. Or should the owner be one of those who *does* try to practice good forestry, highgrading on other land hampers his efforts. He has a long and hard pull ahead—as we all know too well—and his buyers will, of course, prefer stumpage or products from the highgraded stands, as long as they last.

By lending our name to highgrading we impede the progress of good forestry.

As members we must always remember the main objective of our professional society: "to advance and protect the interests and standards of the profession of forestry."

But the customer wanted it and the customer must be right. We probably still have doctors with us who treat patients according to their wishes instead of in accordance with their professional convictions. But I believe they are becoming fewer in number.

Perhaps some of us have planted trees off-site, contrary to our better knowledge. Perhaps the nursery sent what they had, not what we ordered. We said: "Oh well, they'll live." They often do live for many years. They may look fine for 10, 20 or more years—as long, or longer, than we have anything to do with the plantation. Then often stagnation, diseases, even sporadic death, may set in and cause all kinds of worry, speculations, and expenses. We knew better when the plantation was made. But our boss, our customer, wanted action so we passed the buck. Doctors would be sued for malpractice if they did such a thing in their own profession.

These two cases of professional ethics are rather clear.

Less clearly appreciated—chances are, but more important—is our professional responsibility toward employment. Our profession will advance faster and more solidly by fitting the best qualified man available into the most useful position vacancy he is capable of filling.

Any deviation from this rule is bound to mean slowing down our professional progress.

But do we always religiously follow this rule?

Do we always get the best possible man for the job?

I do not need to go into employment for political or similar glaring nonprofessional reasons. This kind of practice is obvious, detestable, but, I believe, it is diminishing within our profession. Unfortunately, our Code of Ethics (Article 23) is not strong enough to sweep out such practices completely.

No, what I am driving at is the employing of the good man, instead of the very best available.

Our profession can develop its full strength only if each man is given an opportunity to exercise his talents to the fullest extent possible, and if each job is filled by the best possible man available. When a position is open, it is common practice to hire a man whom we can easily reach without making it widely known that the job is vacant.

The good man may be very good, but he may not be the very best that we could have had. Here, as in so many other situations, "the good is the worst enemy of the best." The good man, or for that matter, the good equipment or technique, is so good that we are apt to be inclined to hang on to it. The poor man, equipment, or technique can much more easily

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be replaced than the good. Therefore, the good may thus impede employment of the best.

The first—and probably most important—factor to improve the employment situation would be to have all employers announce job vacancies to the entire profession. Jobs are of vital professional concern and as well—needless to say—of vital concern to the individuals desirous of bettering themselves professionally. Today many position openings, especially in public employment, are made widely known. Far more are not made known at all, and hardly any are advertised in the only medium reaching the entire profession—the JOURNAL OF FORESTRY. (If there is a time deadline loose leaves could be enclosed in the JOURNAL just prior to distribution to members).

Open competition for position vacancies, as proposed, will not necessarily require more work on the part of the employers. For the conscientious employer who writes letters to possible contacts and prospects, this proposal will probably make it a whole lot easier to find the right man he is looking for. The job description itself will narrow down the possibilities considerably, and much of the preliminary screening can, if necessary, be organized into a routine process, thus lightening the task of the evaluating panel.

SVEND O. HEIBERG

Division of Silviculture Call for Annual Meeting Papers

The 1960 annual meeting of the Division of Silviculture will be held on Tuesday, November 15, in Washington, D. C. There will be morning and afternoon sessions.

Correspondence relating to the Division of Silviculture should be addressed to Dr. J. H. Buell, chairman, Yale School of Forestry, 205 Prospect St., New Haven 11, Conn. Society members who wish to present papers should submit, in triplicate, the following information: (1) title; (2) short abstract; (3) name and address of the author; (4) name and address of the organization represented; (5) time required for presentation; and (6) type of projection equipment required. This information must be received prior to May 15, 1960 to be considered.

The program will be made up by the executive committee of the Division by selection of papers from the proposals received. Papers that can be presented in 15 minutes or less are favored, and none will be considered which require more than 20 minutes.

Authors of papers that are selected will be notified by June 15.

This is the last call for papers that will be issued by the Division of Silviculture.

FRANK W. WOODS
Secretary,
School of Forestry,
Duke University, Durham, N. C.

Committee on Civil Service Meets with U. S. Forest Service

Upon receipt of several letters and resolutions expressing concern over new U. S. Civil Service policies with respect to the examinations for Forester and Forester (Range Management), your Chairman asked C. K. Lyman, director of the Division of Personnel Management of the U. S. Forest Service, to call a conference to discuss the situation.

At this conference, held in Washington, D. C., on February 18, were Clare W. Hendee, assistant chief of the Forest Service (Administration); Mr. Lyman; and Kenneth M. Daniels, in charge of personnel recruitment and qualifications. Representing both the forestry schools and the Council of the SAF were George A. Garratt, Yale University, S. O. Heiberg, College of Forestry at Syracuse, and R. J. Preston, North Carolina State College; together with S. G. Fontanna, University of Michigan, and Henry Clepper, SAF executive secretary.

Mr. Daniels explained the Forest Service position. All aspects of Civil Service policy were frankly and fully discussed. The Forest Service will restudy its position, and publish full explanation in the JOURNAL OF FORESTRY in an early issue. Reprints of this article will be sent to the forestry schools and Sections as soon as they are available.

We are also requesting the officers of the Division of Education to invite Mr. Daniels to discuss the matter at the annual meeting in Washington, D. C., on November 16. Thus all who are interested will have an opportunity

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to understand the problem and make known their position.

R. J. PRESTON, *Chairman*
SAF Committee on Civil Service

Home Study Education in Forestry and Conservation

The following information is published for members of the Society of American Foresters, a number of whom have directed inquiries to the executive office about the North American School of Conservation, a correspondence school doing business at 1038 South LaBrea Avenue, Los Angeles 19, Calif.

This school formerly advertised its name as the "Forestry and Wildlife Course, a Training Program of Home Study Educators."

On November 15, 1957 the Federal Trade Commission issued Consent Order 6795 of which the following is a verbatim transcript from the Commission's News Summary of that date:

"The Federal Trade Commission today approved a consent order prohibiting Home Study Educators, a Los Angeles, Calif., correspondence school, from misrepresenting its correspondence course in fish, forestry and wildlife, its business organization, and opportunities afforded purchasers of the course.

"The Commission adopted an initial decision by Hearing Examiner Robert L. Piper containing an order agreed to by the firm and the Commission's Bureau of Litigation.

"The firm, located at 1036-38 South LaBrea Ave., in Los Angeles, is the partnership of Gordon L. Van der Boom, John J. McNaughton, and Arnold Heiderich, who also are joined in the order.

"A Commission complaint, issued May 14, had charged the firm with falsely advertising the instruction course in national magazines, brochures, and other promotional literature. For example, the complaint alleged, the course does not, as claimed, cover essential requirements for all positions with the fish, forestry, and wildlife departments of each of the States and the Federal Government.

"In addition to prohibiting this claim in the future, the order provides that the parties must not represent:

"That testimonials used in advertisements are unbiased and unsolicited when they are not;

"That they provide a placement service for graduates or help obtain civil service positions;

"That, contrary to fact, an expert on fish, forestry, or wildlife is on the staff;

"That they provide consultation service or personal counseling to purchasers, unless this is true;

"That the course is offered at a

saving unless the claimed saving is based upon its usual price.

"The parties also are forbidden to misrepresent (1) the necessary educational requirements to qualify for positions in these fields, (2) the opportunities for employment in the fields, and (3) the salaries and opportunities for advancement.

"The agreement is for settlement purposes only and does not constitute an admission by the parties that they have violated the law."

The National Home Study Council of Washington, D. C. is the national accrediting agency for education by correspondence. The North American School of Conservation is not a member of this Council and is not eligible for membership.

The North American School of Conservation should not be confused with the National School of Forestry and Conservation, 2144 P Street, N.W., Washington 7, D. C. The latter school offers home study courses in forestry, soil conservation, and wildlife conservation. Its director is Charles H. Stoddard, a professional forester.

HENRY CLEPPER
Executive Secretary

ROBERT D. MCCULLEY

New Associate Editors Appointed to JOURNAL Board

President Chas. A Connaughton in February announced new appointments as associate editor to the editorial board of the JOURNAL as follows: Otis F. Hall will succeed George H. Schroeder for Forest Management and Engineering; Robert D. McCulley relieves John W. Duffield in the field of Silviculture; Lansing A. Parker succeeds Lee E. Yeager for Forest-Wildlife Management and Recreation; Scott S. Pauley follows Philip C. Wakeley in the field of Forest Genetics and Artificial Regeneration; and Sidney Weitzman becomes new editor for Watershed Management, succeeding Robert E. Dils. Appointments are for a two-year term. James S. Bethel, C. Allen Bickford, Robert L. Furniss, Lee M. James, Charles E. Poulton, and William E. Reifsnyder, previous members of the board with short periods of service, were reappointed.

Brief sketches of the professional background and experience of the new associate editors follow:

Otis F. Hall is professor of forest management in the Department of Forestry and Conservation at Purdue University. He received his undergraduate training at Oberlin College in Ohio. Following two years of service in the Pacific Theater with the U. S. Army Air Force during World War II, he returned to school to obtain the Master degree in forestry from Yale University in 1948. He then spent nine years on the faculty of Minnesota's School of Forestry, teaching forest management, economics, and policy, as well as other courses. In 1957 he transferred to his present position at Purdue. In addition to teaching and research he has acted

OTIS F. HALL

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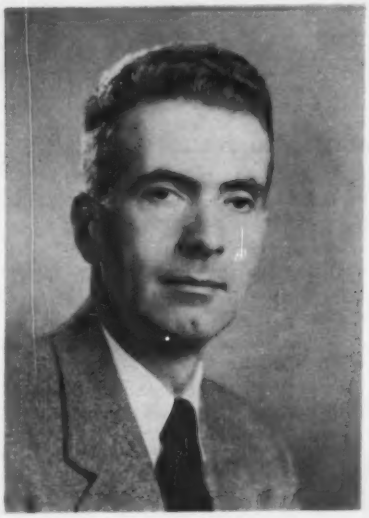
After graduating in liberal arts from Pomona College, Calif., in 1935 Robert D. McCulley received his training in forestry at the University of California. Brief experience on the Sierra National Forest and at the Blacks Mountain Experimental Forest preceded his appointment to the Prairie States Forestry Project. For two years thereafter he was in charge of a planting district in southern Kansas.

On transferring to the Southern Forest Experiment Station in 1940, Mr. McCulley was assigned first to the Upper White River flood control survey, then to seed testing and seed research, and then to the Olustee Experimental Forest at Lake City, Fla., where he was placed in charge. Here he worked on the silviculture and management of the slash and longleaf pine of the flatwoods.

After six years at Lake City, Mr. McCulley was appointed Research Center leader at Franklin, Va., in charge of the Tidewater Research Center of the Southeastern Forest Experiment Station.

For the past seven years Mr. McCulley has been in charge of forest management research at the Lake States Forest Experiment Station. He is responsible for research on the silviculture and management of conifers and hardwoods in Michigan, Minnesota, and Wisconsin plus study of windbreak establishment and care in the Northern Plains.

Mr. McCulley is currently chairman of the Program Committee of the Upper Mississippi Valley Section of the Society, and is a member of the American Forestry Association, Soil Conservation Society, and the Minnesota Academy of Science.



SCOTT S. PAULEY

Lansing A. Parker, assistant director of the Bureau of Sport Fisheries and Wildlife, Department of the Interior, received his professional education at the University of Minnesota, obtaining a B.S. degree from the School of Forestry in 1935.

After graduation he was with the Soil Conservation Service for five years where he served progressively as camp forester in the C.C.C. program, project forester, project biologist, and area biologist. In the latter position he planned and directed the wildlife phase of S.C.S. activities in Minnesota.

From 1940 to 1943 he was associated with the Minnesota Division of Fish and Game. In the latter year he accepted an assignment with the Rubber Development Corporation of the Reconstruction Finance Corporation and spent a year and a half in Brazil, searching for potential sources of rubber as well as serving as production technician in the northeastern part of that country.

Upon returning to the States at the end of 1944, he spent six months more with the Minnesota Division of Fish and Game, in charge of the Federal Aid program.

In 1945 he joined the staff of the Fish and Wildlife Service in charge of the Section of Lands and Development in the Branch of Federal Aid. He was promoted to the position of

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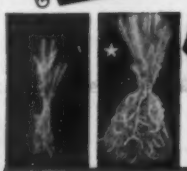

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assistant chief of the Branch of Federal Aid in 1948, with responsibility for the Federal Aid in Wildlife Restoration program.

Following the reorganization of the Fish and Wildlife Service in 1956, Mr. Parker was appointed an assistant director of the Bureau of Sport Fisheries and Wildlife.

He is a charter member of The Wildlife Society as well as a member of the SAF.

Scott S. Pauley is professor of forestry, School of Forestry, University of Minnesota. He received his B.S. degree in forestry from the University of Minnesota in 1939, his M.S. from Michigan State University in 1942, and his Ph.D. from Harvard in 1947. His first professional work as a forester was with the Wisconsin Conservation Department during 1939-1940. He then was an instructor in forestry at Michigan State during 1942-1943, leaving that institution for service in the U. S. Navy, 1943-1945. He was an assistant professor at Harvard and then lecturer in forest genetics with the Maria Moors Cabot Foundation for Botanical Research during the period 1947-1955. He joined the Minnesota faculty in 1955.

Dr. Pauley has served as chairman of the SAF Committee on Forest Tree Improvement and has participated actively in Forest Tree Improvement Committees in the Northeast and Lake States. He is currently a vice president and director of the Forest Genetics Research Foundation. He is a member of the AAAS, the American Institute of Biological Sciences, and other scientific organizations. Author of numerous articles in the field of forest tree improvement, Dr. Pauley was a member of the U. S. Forestry Delegation to the U.S.S.R. in 1959.

Sidney Weitzman is chief of the Division of Watershed Management Research of the Lake States Forest Experiment Station. This new division at the Station, formed in 1956, is developing a program of basic research in the fields of bog and swamp hydrology and ground-water behavior.

Mr. Weitzman received his B.S. and M.S. degrees from the New York College of Forestry, and on graduation in 1938 began his Forest Service career with the Timber Salvage Administration in Massachusetts. From 1939 to 1941 he worked on flood control surveys for the Southern Forest Experiment Station. During World War II he served as a pilot with the Army Air Force in the European Theater. Returning to the Forest Service in 1946 he joined the Division of Flood Control Surveys of the Northeastern Forest Experiment Station and from 1948 to 1956 was Research Center leader at Elkins, W. Va., working on timber and watershed management and integration of land use in mountain areas. Mr. Weitzman's articles in both the technical and popular fields have appeared in the *Yearbook of Agriculture, American Geophysic Union Transactions, Soil Science Society of America Proceedings,* the *Journal of Soil and Water Conservation, Forest Science, Southern Lumberman,* and numerous Department of Agriculture publications.

Charles W. Boyce (1894-1960)

Charles W. Boyce, 66, of New York City, died January 11.

Graduated at the University of Michigan in 1914, he subsequently did graduate work there in forestry.

Entering the U. S. Forest Service, he worked on various national forests in the Pacific Northwest and in Alaska. Later he was transferred to the Washington, D. C., office where he specialized in the economics of the forest products industry, especially in pulp and paper.

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During World War I he was in charge of an aerial topographic school for the Army, and was subsequently commanding officer of the 65th Photo Section.

Mr. Boyce left the Forest Service in 1928 to become executive secretary of the American Paper and Pulp Association which position he held until 1940. Since 1951 he had been consultant to the American Newspaper Publishers Association.

Aldo Pavari (1888-1960)

Aldo Pavari of Florence, Italy, an Honorary Member of the Society of American Foresters, died January 17, 1960.

Born August 16, 1888 in Rome, Professor Pavari completed graduate courses in forestry at the University of Milan in 1910. There followed a year as a specialist in forestry in Germany.

During World War I he was an officer in the Italian Army, rising from first lieutenant to major.

In December 1916 he was appointed inspector of the Royal Forest Service in Italy where he served until October 1924 when he became professor of

forestry at the University of Florence (Firenze).

Appointed director of the Forest Experiment Station of Florence in April, 1929, he also was named professor of forest botany at the university in November, 1945.

Professor Pavari was a past president of the International Union of Forest Research Organizations. He was a delegate to the several World Forestry Congresses, and was chairman of the FAO Subcommission for Forest Problems of Mediterranean Countries.

Elected a Corresponding Member of the Society of American Foresters in 1947, he was advanced to Honorary Member in 1955.

In addition, he was a member of numerous Italian and international forestry and scientific societies.

Claude R. Tillotson (1883-1959)

Claude Raymond Tillotson died at his home in Berkeley, Calif., October 27, 1959.

Mr. Tillotson was born in Omaha, Nebr., October 31, 1883. He was a graduate of the University of Nebraska, with a B.S. in forestry, in 1909. In July of that year he entered the U. S. Forest Service and in the early part of his career served in various capacities in Nebraska, Pennsylvania, Connecticut, and Colorado. He retired October 31, 1948 after 39 years' service. At the time of his retirement he was with the Division of State and Private Forestry in the California Region of the Forest Service. He became a member of the SAF in 1911, and was also a member of the Society of Sigma Xi.

Henry H. Tryon (1888-1960)

Henry Harrington Tryon, 71, of Cornwall-on-Hudson, N. Y., died January 28, 1960. He was a consulting forester and former director of the Black Rock Forest in the Bear Mountain region of New York State.

Born June 7, 1888, in Rumford, R. I., he was educated at Harvard University, receiving the A.B. degree in 1912 and the M.F. degree in 1913.

He began his forestry career with a teaching position at the College of Forestry, Syracuse, N. Y. During World War I, he was with the Army Bureau of Aircraft Production in Washington, D. C., then served for four years as extension forester of South Carolina.

In 1929, Mr. Tryon became director of the Black Rock Forest, a privately owned research and demonstration forest, and continued in this position for nearly two decades. On his retirement, he went into consulting forestry.

Howard R. Krinbill (1884-1960)

Howard Ruh Krinbill, 75, of Webster, N. Y., died Februray 28.

Born March 7, 1884 in Crown Point, Ind., he attended the Biltmore Forest School, receiving the B.F. and F.E. degrees in 1909 and 1911.

He began his forestry career as a timber estimator for various lumber companies in the East. In 1921 he joined the Internal Revenue Bureau as a valuation engineer for the southern pine region. His headquarters was in Washington, D. C., during 1932-1939, and in New York City until his retirement in 1949.

In recent years he was a consulting engineer.

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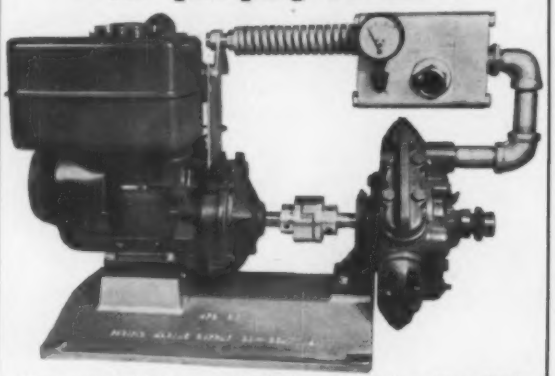

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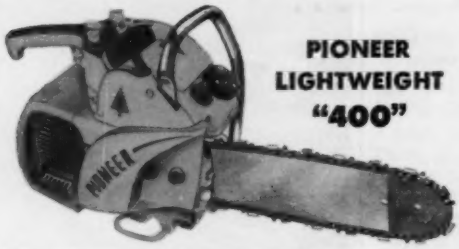

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Northern Rocky Mountain Section News Letter

The Northern Rocky Mountain Section recently distributed the first issue of its newsletter which will be published quarterly, beginning with the February, No. 1, release.

Richard T. Marks, vice chairman of the Section, is editor. His address is Extension Service, Montana College, Bozeman, Mont., where he is extension forester.

The Section now has two Chapters —Missoula and Libby—and two more are proposed for Bozeman and the Kalispell-Polson area.

Ozark Section Holds Winter Meeting in Little Rock

The annual winter meeting of the Ozark Section was held February 12 and 13 in the La Fayette Hotel, Little Rock, Ark.

A symposium on forest planning was the feature of the opening morning session, with Gordon R. Condit as moderator.

The panel speakers were John R. Stone of International Paper Company, Hot Springs, Ark.; Jack W. Hambrick of Ouachita National Forest, Hot Springs, Ark.; Harold G. Armstrong, Ouachita National Forest, Mt. Ida, Ark.; James Bean, Soil Conservation Service, Monticello, Ark.; and Richard F. Kennedy of the Crosset Company, Crossett, Ark.

Featured on the afternoon program was a panel discussion on the forester's relationships with people. John C. Burwell was moderator.

Panel members were Kenneth W. Bradley of the Ouachita National Forest, Hot Springs, Ark.; M. Lee Markell, Jr., Dierks Forests, Inc., DeQueen, Ark.; Fred C. Gragg, International Paper Company, Camden, Ark.; and Lee C. Fine, Missouri Conservation Commission, Jefferson City, Mo.

Following a social hour, the Section's annual dinner was served, with 235 members, ladies, and guests present. Henry Clepper, SAF executive secretary, was the after-dinner speaker.

The annual business meeting was held on Saturday morning, February 13. Richard C. Smith, Section chairman, presided. Harold S. Winger, vice chairman, made a report on membership. M. Lee Markell, Jr., secretary-treasurer, reported on the previous Section meeting and on finances.

Following the close of the meeting, the members made a tour of the newly completed building housing the Arkansas State Forestry Commission.

New York Section Elects Officers

At the winter meeting of the New York Section in Albany, January 28 and 29, the following officers were elected: Edward J. Whalen, chairman, New York State Conservation Department, Jamestown; C. Eugene Farnsworth, secretary-treasurer, State University College of Forestry, Syracuse; and Robert Morrow, Cornell University, and Shelley Potter, State University College of Forestry, to the executive committee.

Southeastern Section Holds Big Winter Meeting

With a record attendance of 394 members and 50 ladies, the Southeastern Section held its winter meeting at Valdosta, Ga., January 28 and 29, at the Valdosta Country Club.

Retiring chairman Leon A. Hargreaves, Jr., presided at the business session. Reports were made by Donald D. Stevenson, chairman of the Membership Committee; by Lawrence C. Walker, secretary-treasurer; by Bishop F. Grant, Section historian; by Frank E. Craven, *Newsletter* editor; and by other committee chairmen. Henry Clepper, SAF executive secretary, briefly discussed Society affairs.

Linton W. Eberhardt was toastmaster at the Section's annual dinner on January 28. The speaker was the Hon. Iris Blitch, Member of Congress from the Georgia 8th District.

H. E. Ruark was moderator at the technical session on the morning of January 29. E. V. Brender presented a paper "Growth of Natural Stands of Loblolly Pine in the Piedmont." Louis Metz reported on his trip to Russia made during the summer of 1959. Lloyd Thorpe discussed "The JOURNAL OF FORESTRY and a Western Viewpoint of the Society."

New officers installed are chairman Donald D. Stevenson of Foley, Fla.; James W. Owens of Tuscaloosa, Ala.,

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chairman-elect; and Robert Swinford of Gainesville, Fla., secretary-treasurer. (Photo on page 287.)

The final event of the meeting was a tour of the Langdale Company's wood preservation and naval stores plant, and modern sawmills, arranged through the courtesy of Harley Langdale, Jr.

Membership Applications and Advancements

Proposals for admission, advancement, and reinstatement received in the Society office during the month of February are listed below.

Action on the eligibility of those proposed for membership as listed below will be taken by the Council as of April 1960.

Communications from the voting members regarding the membership eligibility of these persons should be received in the Society office prior to that date.

Alaska Section

Junior Grade

Bennett, J. E., Forester, USDA, Juneau, Alaska. Mt. State Univ., BSF, 1950.

Johnson, R. A., Dist. Ranger, USFS, Ketchikan, Alaska. Univ. Minn., BSF, 1937.

Member Grade

Fixsen, W. G., Forester, Bur. of Land Mgmt., McGrath, Alaska, Iowa State College, BSF, 1950.

Allegheny Section

Student Grade

PENNSYLVANIA STATE UNIVERSITY

Ettinger, G. E. — Hutchison, B. A.
George, T. A. — Jones, R. A.

WEST VIRGINIA UNIVERSITY

Barnes, J. R. — Harman, D. M.

Member Grade

Kerr, R. S., Lbr. Salesman, Weyerhaeuser Sales Co., Mechanicsburg, Pa. (Junior 1952).

MacNeill, R. L., Asst. Dist. Ranger, USFS, Bartow, W. Va. Univ. of Mass., BSF, 1956 (Junior 1956).

Nelson, C. N., Veneer Buyer, Kane, Pa. (Junior 1952).

Sushko, W. C., Watershed Forester, Bur. of Water Supply, Baltimore, Md. (Junior 1956).

Zimmer, M. R., Crestmont Dr., Honesdale, Pa. (Junior 1953).

Appalachian Section

Student Grade

NORTH CAROLINA STATE COLLEGE

Fox, J. H.

Junior Grade

Cabell, L. E., Service Forester, Va. Div. of Forestry, Charlottesville, Va. W. Va. Univ., BSF, 1959.

Kochenderfer, J. N., Student, Duke Univ., Durham, N. C. W. Va. Univ., BSF, 1959.

Martin, A. L., Asst. Area Mgr., Riegel Paper Corp., Bolton, N. C. (Reinstatement).

McConaughy, D. L., Forester, W. Va. Pulp & Paper Co., Georgetown, S. C. State Univ. of N. Y., BSF, 1953.

Member Grade

Benedict, D. G., Student, Duke Univ., Durham, N. C. (Junior 1951).

Brooks, M. T., Service Forester, Va. Div. of Forestry, Tappahannock, Va. N. C. State, BSF, 1956 (Junior 1956).

Holmes, R. F., Forester, Va. Div. of Forestry, Farmville, Va. Mich. State, BSF, 1947 (Junior 1956).

Lewis, T. D., Cons. Forestry, Union Bag-Camp Paper Corp., Savannah, Ga. Univ. Ga., BSF, 1950 (54R58).

Miller, R. J., Forester, Tilghman Lbr. Co., Sellers, S. C. N. C. State, BSF, 1956 (Junior 1956).

Rettberg, H. C., Woods Supt., Poinsett Lbr. & Mfg. Co., Pickens, S. C. (Reinstatement).

Sluder, E. R., Research Forester, USFS, Asheville, N. C. N. C. State, BSF, 1956 (Junior 1956).

Affiliate Grade

Ivy, F. R., Sr. Forester, Rome Kraft Co., Rome, Ga.

Tyler, W. A., Dist. Mgmt. Chief, Va. Div. of Forestry, Waverly, Va.

Central Rocky Mountain Section

Junior Grade

Borden, T. B., State Forester, Colo. State Forest Service, Fort Collins, Colo. (Reinstatement).

Crane, B. K., Div. Chief, USFS, Denver, Colo. Utah State, BSF, 1935.

Member Grade

Black, P. E., Research Asst., Colo. State Univ., Fort Collins, Colo. Univ. Mich., BSF, 1956, Colo. State, MF, 1958 (Junior 1956).

Landgraf, A. E., Entomologist, Rocky Mtn. Forest & Range Expt. Sta., Fort Collins, Colo. Colo. State, BSF, 1950, Duke Univ., MF, 1956 (Junior 1956).

West, J., 1343 Wyoming Ave., Cody, Wyo. (Junior 1953).

Central States Section

Student Grade

PURDUE UNIVERSITY

Wood, E. W.

Member Grade

Cooper, G. A., Research Forester, Makanda, Ill. (Junior 1953).

Crabb, W. F., Paper Products Sales, Dyer, Ind. (Junior 1952).

Gerlach, J. R., Cleveland Parks, Lakewood, Ohio (Junior 1952).

Haack, L. E., Dist. Ranger, USFS, Ironton, Ohio (45R55).

Johnson, R. E., Ranger, Ohio Div. of Forestry, Willoughby, Ohio (Junior 1953).

Lewis, W. K., Farm Forester, Jerseyville, Ill. (Junior 1953).

Peterson, K. R., Asst. Prof., Univ. of Ill., Urbana, Ill. Univ. Mass., BSF, 1953, Yale Univ., MF, 1955 (Junior 1955).

Young, R. F., Asst. Dist. Ranger, USFS, Elizabethtown, Ill. (Junior 1953).

Associate Grade

Mooney, M. B., Economist, Central States Forest Expt. Sta., Columbus, Ohio.

Columbia River Section

Student Grade

OREGON STATE COLLEGE

Bellamy, R. B. — Olson, F. W.
Clark, M. N. — Page, R. S.

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Hanson, R. P. Pender, J. H.
Inglis, L. H. Richards, D. P.
Olsen, R. J. Schultheis, W. A.
Scott, B. G.

Junior Grade

Chan, G. K., Asst. Logging Eng., J. Neils Lbr. Co., Glenwood, Wash. Univ. Wash., BSF, 1957.
Harshman, E. P., Forester, USFS, Medford, Ore. (Affiliate 1951).
Jorgensen, C. G., Forest Supv., Gifford Pinchot Natl. Forest, Vancouver, Wash. (Affiliate 1951).
O'Brien, P. W., Property Appraiser, State Tax Comm., Hillsboro, Ore. Mich. State, BSF, 1951.
Thompson, R. K., Logging Eng., Puckett & Schere, Klamath Falls, Ore. Ore. State, BSF, 1942.

Member Grade

Clemmons, J. W., Forest Statistician, Crown Zellerbach Corp., Portland, Ore. Purdue Univ., BSF, 1956 (Junior 1956).
Davies, W. G., Highway Eng., USFS, Corvallis, Ore. Ore. State, BSF, 1956 (Junior 1956).
Rappel, D. C., Forester, USFS, Marlin, Ore. Mich. State, BSF, 1956 (Junior 1956).
Smith, D. H., Forester, USFS, Glide, Ore. Ore. State, BSF, 1956 (Junior 1956).

Affiliate Grade

Woods, R. L., Farm Forester, State Dept. of Natural Resources, Kelso, Wash.

Gulf States Section

Member Grade

Beard, P. O., Dist. Forester, Tenn. River Pulp & Paper Co., Ripley, Miss. Univ. Mich., BSF, 1956 (Junior 1956).
Thompson, W. S., Asst. Prof., Louisiana State Univ., Baton Rouge, La. (Junior 1951).

Associate Grade

Nation, H. A., Field Specialist, The Dow Chemical Co., Greenville, Miss.

Inland Empire Section

Student Grade

UNIVERSITY OF IDAHO

Best, R. K. Hoppin, W. W.
Bledsoe, J. B. Johnson, R. C.
DeMeyer, J. R. Kisska, L.
Ewing, W. R. Polz, E. A.
Hauxwell, D. L. Wisdom, H. W.

Member Grade

Markley, J. H., Research Dept., Potlatch Forests, Inc., Lewiston, Idaho. (Junior 1953).
Swift, D. D., Forester, Lincoln Lbr. Co., Inchelium, Wash. (Junior 1953).

Affiliate Grade

Robinson, V. S., Forest Research Supv., Potlatch Forests, Inc., Lewiston, Idaho.

Intermountain Section

Student Grade

UTAH STATE UNIVERSITY

Howell, D. E. Lund, H. G.

Junior Grade

Kearns, F. W., Asst. Prof., Utah State Univ., Logan, Utah (Reinstatement).

Member Grade

Cooperrider, B. K., Forester, USFS, Ogden, Utah. Colo. State, BSF, 1949 (Junior 1956).
Lee, H. S., Forester, USFS, Lamoille, Nev. Utah State, BSF, 1956 (Junior 1956).

Kentucky-Tennessee Section

Junior Grade

Henninger, C. M., Woodland Conservationist, Cons. Service, Cleveland, Tenn. (Reinstatement).
Thorbjornsen, E., Forest Geneticist, Agric. Expt. Sta., Knoxville, Tenn. Univ. Wash., BSF, 1954, MS, 1956.

Member Grade

Morrison, A. A., Asst. Dist. Forester, Tenn. Forestry Div., Erin, Tenn., Univ. Ga., BSF, 1956 (Junior 1956).
Orr, J. V., Forestry Administrative, Greenville, Tenn. (50R55).
Towle, E. L., Forester, USFS, Winchester, Ky. Univ. Maine, BSF, 1956 (Junior 1956).

New England Section

Student Grade

UNIVERSITY OF MAINE

Gates, B. L. Solari, J. E.
Groff, R. W. Vogellus, J. T.

UNIVERSITY OF MASSACHUSETTS

Giebel, F. B. Morin, D. N.
Lemoine, N. W. Richards, R. H.
Stevens, D. C.

UNIVERSITY OF NEW HAMPSHIRE

Allen, J. K. Lacasse, N. L.
Eaton, J. S. McHugh, W. J.
Gienty, D. F. McKay, D. P.
Kent, C. A. Merrill, C. G.
Kinder, R. G. Naumann, H. A.
Kolosseus, M. T. Noyes, D. R.

Junior Grade

Bartlett, C. G., Forester, USFS, Conway, N. H. Univ. N. H., BSF, 1953.

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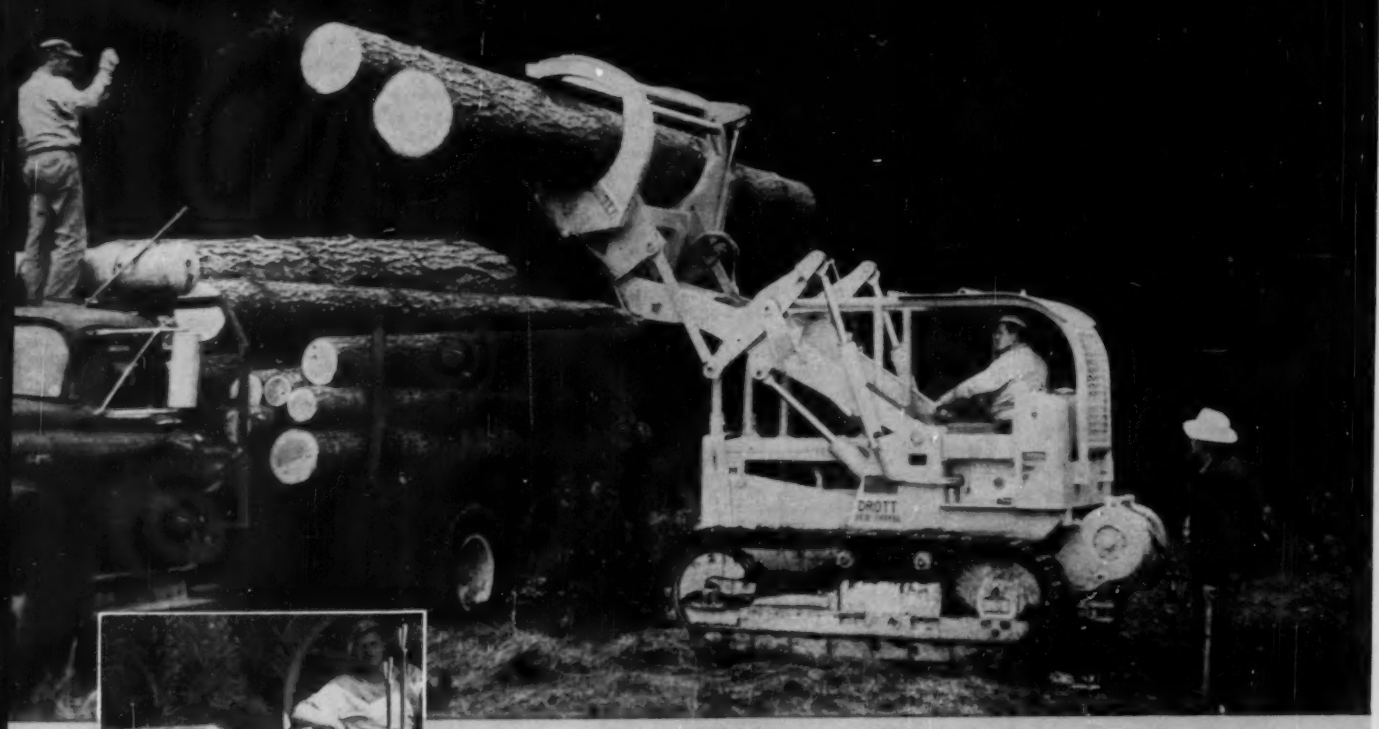

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"I'd figured to lose money or at best break even on our TD-9 Skid-Grapple's first job," reports contract-logger W. W. McKee. "It was a slack time job, taken to keep the crew busy.

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Olsen, J., Forest Ranger, Conn. Park & Forest Comm., Voluntown, Conn. (Affiliate 1953).

Member Grade

Fowler, D. P., Student, Yale Univ., New Haven, Conn. Yale Univ., MF, 1956 (Junior 1956).

Leak, W. B., Northeastern Forest Expt. Sta., Laconia, N. H. (Junior 1953).

Pierce, R. S., Project Leader, Northeastern Forest Expt. Sta., Laconia, N. H. (Junior 1953).

Rideout, L. B., Forester, Hearst Publishing Co., Inc., Brunswick, Maine. Univ. Maine, BSF, 1940 (Junior 1956).

Affiliate Grade

Voboril, J. W., Ranger, Salmon River Forest Area, Lebanon, Conn.

New York Section

Student Grade

STATE UNIVERSITY OF NEW YORK

Bianchi, H. S.

Junior Grade

White, E. F., Forester, N. Y. State Cons. Dept., Catskill, N. Y. State Univ. N. Y., BSF, 1954.

Northern California Section

Student Grade

UNIVERSITY OF CALIFORNIA

Beam, P. H. Harrell, R. D.

Northern Rocky Mountain Section

Student Grade

MONTANA STATE UNIVERSITY

Bentzen, R. C. Landgraf, L. K.

Dobson, R. S. Morton, D. H.
Emerson, J. C. Pittman, G. D.
Fudge, C. W. Smith, D. L.
Thullen, R. J.

Junior Grade

Beebe, J. D., Forester, USFS, Missoula, Mont. (Reinstatement).

Member Grade

Covey, W. H., Woods Boss, Helan Logging Co., Missoula, Mont. (Junior 1953).

Harvey, J. J., Dist. Forest Ranger, Townsend Ranger Dist., Townsend, Mont. (Junior 1953).

Heckman, J. H., Asst. Ranger, Warland Ranger Sta., Libby, Mont. (Junior 1953).

Lowery, D. P., Technologist, USFS, Missoula, Mont. (Junior 1951).

Mar Jaquish, E. D., Ranger, Libby Ranger Dist., Libby, Mont. (Junior 1953).

Keeney, K. A., Asst. Regional Forester, USFS, Missoula, Mont. (34R53).

Puckett, J. V., Dist. Forest Ranger, Powell Ranger Sta., Lolo, Mont. (Junior 1953).

Affiliate Grade

Neal, C. F., Forester, USFS, Stevensville, Mont.

Associate Grade

Turner, R. F., Highway Eng., USFS, Libby, Mont.

Ozark Section

Student Grade

UNIVERSITY OF MISSOURI

Hurlbut, D. D. Williams, F. R.

Junior Grade

Carey, R. R., Dist. Supv., International Paper Co., Camden, Ark. State Univ. N. Y., BSF, 1932.

Eakin, F. L., Dist. Forester, Deltic Farm & Timber Co., Inc., El Dorado, Ark. Pa. State, BSF, 1951.

Member Grade

Gruening, W. E., Sales Trainee, Dierks Forests, Inc., Kansas City, Mo. Iowa State, BSF, 1955 (Junior 1956).

Wasson, G. W., Asst. Ranger, USFS, Hot Springs, Ark. La. State, BSF, 1950 (Junior 1956).

Affiliate Grade

Bradley, J. B., Forester, International Paper Co., Sheridan, Ark.

Calhoun, T. M., Route 2, Box 56, Star City, Ark.

Freeman, B. L., Mgmt. Forester, Ark. State Forestry Comm., Fayetteville, Ark.

Simmons, J. L., Self Employed, Monticello, Ark.

Young, B. G., 315 Rock St., Sheridan, Ark.

Puget Sound Section

Student Grade

UNIVERSITY OF WASHINGTON

Howry, R. S. Ronholt, D. O.
Prichard, J. A. Ryckman, J. D.

Junior Grade

Robinson, D. L., Dist. Ranger, USFS, Port Angeles, Wash. (Reinstatement).

Member Grade

Feasey, E. C., Forest Eng., Crown Zellerbach Corp., Neah Bay, Wash. Ore. State, BS, 1959, State Univ. N. Y., BS, 1952 (Junior 1956).

Hawley, R. J., Asst. Dist. Administrator, Dept. of Natural Resources, Raymond, Wash. Univ. Wash., BSF, 1956 (Junior 1956).

Lorello, J. J., Photogrammetrist, Dept. of Natural Resources, Ellensburg, Wash., Utah State, BSF, 1950 (Junior 1950).

Rosenberg, H. L., Forester, U. S. Plywood Corp., Seattle, Wash. Univ. Minn., BSF, 1956 (Junior 1956).

Affiliate Grade

Campbell, R. K., Instructor, Univ. of Wash., Seattle, Wash.

Southeastern Section

Student Grade

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Brown, J. E. James, E. I.
Chancey, J. E. O'Gara, J. D.
Clearman, F. W. Wade, L. H.
Greer, J. E. Westmoreland, D. L.

UNIVERSITY OF GEORGIA

Braddock, L. W. Preston, A. W.
Fulmer, P. T. Scarborough, J. J.
Glenn, P. M. Spivey, W. R.
Hatcher, R. D. Trammell, R. B.
Matthews, R. M. Woodard, C. D.
Worthington, L. A.

Junior Grade

Carter, M. C., Research Forester, Macon Research Center, Macon, Ga. (Affiliate 1955).

Shelton, L. P., Dist. Forest Mgr., Owens-Illinois, Jacksonville, Fla. (Reinstatement).

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UNIVERSITY OF FLORIDA

Coleman, M. C. Tolotti, C. W.

Member Grade

Bennett, W. M., Forester, Huxford Bros., Perry, Fla. (Junior 1953).

Curry, J. C., Forester, Buckeye Cellulose Corp., Foley, Fla. (Junior 1953).

Dowling, B. J., Logging Eng., Buckeye Cellulose Corp., Foley, Fla. (Junior 1953).

Henry, G. W., Wood Buyer, Southeast Tbr. Div., Rayonier Inc., Jessup, Ga. Univ. Ga., BSF, 1956 (Junior 1956).

Howard, E. R., Asst. Chief, Fla. Forest Service, Tallahassee, Fla. (50R54).

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Jones, W. M., Asst. Dist. Forester Mgmt., Ga. Forestry Comm., Dalton, Ga. Univ. Ga., BSF, 1956 (Junior 1956).

McGregor, W. H. D., Research Forester, Southeastern Forest Expt. Sta., Lake City, Fla. (Junior 1953).

Morris, G. S., Area Forester, Buckeye Cellulose Corp., Foley, Fla. (51R54).

Schores, D. D., Area Forester, Buckeye Cellulose Corp., Foley, Fla. (Junior 1953).

Zontek, F., Sr. Forester, Ga. Kraft Co., Macon, Ga. La. Poly. Tech., BSF, 1952 (Af1953J1954).

Affiliate Grade

Reichert, J. E., Forester, USFS, Andalusia, Ala.

Sanders, H. M., Forester, St. Mary's Kraft Corp., St. Mary's, Ga.

Southwestern Section

Junior Grade

Brokaw, D. H., Div. Director, Southwest Forest Industries, Inc., McNary, Ariz. Colo. State, BSF, 1953.

Member Grade

Keesey, J. C., Rowland Nursery, Albuquerque, N. Mex. Iowa State, BSF, 1954 (Junior 1955).

Wykert, P. V., Recreation Planner, Natl. Park Service, Santa Fe, N. Mex. Univ. Idaho, BSF, 1947 (Junior 1954).

Southern California Section

Junior Grade

Horton, L. J., Recreation Asst., USFS, Pasadena, Calif. Ore. State, BSF, 1956.

Affiliate Grade

Arndt, A. M., Deputy Forester, Los Angeles County Dept., Los Angeles, Calif. (Reinstatement).

Upper Mississippi Valley Section

Student Grade

IOWA STATE UNIVERSITY

Messerschmidt, D. K.

UNIVERSITY OF MINNESOTA

Alm, A. A. Oberg, V. E.
Edvenson, D. M. Peterson, D. R.
Lang, T. D. Stone, D. B.
Mohn, C. A. Turner, M. G.

Junior Grade

Gaylord, G. T., Regional Forester, Minn. Div. of Forestry, Cloquet, Minn. (Reinstatement).

Affiliate Grade

Pitt, L. R., Ordnance Div., Berlin Command, APO 742, New York, N. Y.

Associate Grade

Kary, G. A., Nursery Mgr., Fort Lincoln Nursery, Bismarck, N. D.

Washington Section

Member Grade

Mason, T. C., Asst. Director, Dept. of Commerce, Washington, D. C. (Reinstatement).

Wisconsin-Michigan Section

Student Grade

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Norton, D. S. Woerpel, L. S.

MICHIGAN STATE UNIVERSITY

Alcock, J. E. Fulk, T. A.
Burns, R. Kielbaso, J. J.
Vander Kolk, M. P.

UNIVERSITY OF MICHIGAN

Loch, E. F.

Junior Grade

Cassidy, M. W., Dist. Forester, Abitibi Corp., Alpena, Mich. (Reinstatement).

Daugherty, P. G., Dist. Ranger, USFS, Three Lakes, Wis. Univ. Mich., BSF, 1953.

Duffy, P. D., Teaching Asst., Univ. of Mich., Ann Arbor, Mich. Univ. Maine, BSF, 1959.

Krumbach, A. W., Research Forester, USFS, Vicksburg, Miss. (Affiliate 1953).

Nelson, D. E., Grad. Student, Univ. of Mich., Ann Arbor, Mich.

Member Grade

Haertle, L. A., Dist. Forester, Wis. Cons. Dept., Lancaster, Wis. Mont. State, BSF, 1952 (Junior 1953).

Poppy, R. E., Forester, USFS, Baldwin, Mich. Mich. State, BSF, 1955 (Junior 1956).

Rateliff, R. C., Tree Clearing Supv., Consumers Power Co., Jackson, Mich. Mich. State, BSF, 1949 (Junior 1956).

Ruetz, E. P., Asst. Dist. Forester, Wis. Cons. Dept., Baldwin, Wis. Utah State, BSF, 1956 (Junior 1956).

Associate Grade

Kabat, C., Research Coordinator, Wis. Cons. Dept., Madison, Wis.

No Section

Corresponding Grade

Taik Kyun, Burm, Sr. Forester, Institute of Agric., Seoul, Korea.

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Forestry News

Forest Fire Total Jumps to 105,000

This past year forest fires went above the 100,000 mark for the first time since 1957, when they hit an all-time low of 83,392, the U. S. Department of Agriculture has announced.

An average of 287 forest fires a day brought out fire fighters from various organizations, according to a preliminary summary compiled by the Forest Service.

A total of 105,191 forest fires were reported in 1959. This is 7,281 more than were reported in 1958. The acreage burned totaled 4,021,782 acres in 1959 as compared to 3,098,618 in 1958.

These figures include reports from state foresters, Forest Service field offices, and the Department of the Interior. A final report will be available about July 1.

Extremely hot dry weather coupled with prolonged winds dried out the forests of northern California and Oregon this past summer, making the fire season one of the worst on record.

Many eastern states and all southern states had more forest fires than California and many reported larger acreages burned. The greatest number of fires was reported in Mississippi—9,834. The largest acreage burned was in Florida, 831,461 acres, most of which were lands with no organized forest fire protection.

Nationwide over $100 million was spent for organized forest fire protection and control last year. This expenditure, the greatest on record, includes funds from the Departments of Agriculture and Interior, and the forestry agencies of 47 states. Of the $54 million spent in the protection and control of fires on state and private lands, 18 percent was furnished by the Forest Service under authorization of the Clarke-McNary Act.

Although lightning caused many of the large fires, man-caused fires increased in number. Most man-caused fires were started by debris burners, smokers, incendiarists, campers, and railroads.

Conservation Award For The Boy Scouts of America

A "conservation citizenship award" was presented to the Boy Scouts of America by Secretary of Agriculture Ezra Taft Benson on February 9 in Washington, D. C. The award was made in recognition of the Scouts' activities in the protection and improvement of the nation's natural resources during the past half-century.

Fifty Explorer Scouts, one from each of the states, took part in the ceremony. They had been chosen to represent their states during Boy Scout Week, February 7-13, in observance of the 50th anniversary of the movement.

Scouts have eaned two million merit badges in conservation and resource use and in agricultural categories since 1911.

The Scouts in turn presented four

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plaques to bureaus in the Department of Agriculture for service to natural resource management. One went to the Forest Service, and was received by Chief R. E. McArdle.

Pomeroy to Direct North Carolina Land Study

Chief forester Kenneth B. Pomeroy of The American Forestry Association has been named director of the association's North Carolina landownership project. This project, the third one undertaken by AFA, will be concerned mainly with the 15 million acres held by 222,000 farmers and 43,000 other small woodland owners in North Carolina. Only eight percent of the state's 19 million acres of forest are under county, state, or federal control. Forest industries own the remainder, about 2.6 million acres.

The North Carolina landownership study will try to provide a yardstick for future planning, particularly in programs involving the small woodland owner. North Carolina is considered to be ideal for such an undertaking because its natural geographic divisions, coastal plain, piedmont, and mountain, make portions of it representative of many other eastern and southern states.

The North Carolina landownership pattern is in sharp contrast to the other states, California and Minnesota, where AFA has made similar studies under the direction of Dr. Samuel T. Dana, dean emeritus, School of Natural Resources, University of Michigan. In California 50 percent of the forest land is in federal ownership, while in Minnesota the state and county holdings aggregate 39 percent with the federal government holding an additional 17 percent.

Mr. Pomeroy will be assisted on the North Carolina project by Dr. James G. Yoho, professor of forest economics, and Mr. William P. Thompson, a Ph.D. candidate, both of Duke University. Dr. Dana will serve in a consulting capacity as will Dr. Richard J. Preston, dean, School of Forestry, North Carolina State College.

The North Carolina project, made possible by a grant from the Mary Reynolds Babcock Foundation, will be undertaken in cooperation with the North Carolina Forestry Association. Other cooperating organizations include North Carolina State College, Duke University, North Carolina Department of Conservation and Development, Institute of Government, U. S. Forest Service, and Soil Conservation Service.

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Finnish Government Honors R. E. Marsh

Raymond E. Marsh, a former assistant chief of the U. S. Forest Service, has been awarded the Order of the White Rose of Finland, for his service in making Finland, and particularly her forestry, known in the United States.

News of this award was contained in a letter to Mr. Marsh dated December 1, 1959, from Ambassador R. R. Seppala of Finland.

The Order of the White Rose, highest ranking civil merit order of Finland, is rarely conferred upon a lay citizen of the United States. Mr. Marsh is the first American forester to be so honored. In 1958, in a similar honor from the Swedish Government, Mr. Marsh was made an Officer of the Royal Order of Vasa.

"We in the Forest Service are proud to see one of our former assistant chiefs so honored," said Richard E. McArdle, chief of the Forest Service. "We have welcomed the Finnish foresters who visited this country to obtain technical forestry information, and we are glad to see one of our men who contributed much to American understanding of Finnish forestry recognized by that government."

Mr. Marsh went to Scandinavia in 1951, after his retirement, to study the forest policies and institutions of these countries which are among the world's pioneers in the development of forestry on a nationwide scale. His observations took the form of a report, *Public Policy Toward Private Forest Land in Sweden, Norway, and Finland,* which was published by the Charles Lathrop Pack Forestry Foundation in 1954.

A graduate of Dartmouth College and the Yale School of Forestry, Raymond Marsh entered the Forest Service in 1910. He retired in 1950 after a career in both administration and research, the last 14 years of which were spent as an assistant chief.

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Public

Arkansas State Forestry Commission Has New Home

After twenty years of being housed in rented or in other state agencies' offices, the Arkansas State Forestry Commission has a beautiful new home in Little Rock. Constructed of native woods and sandstone, it provides adequate and functional quarters for the personnel of the state forester's staff.

On the building's two floors, the various offices and rooms are handsomely panelled in some 18 different species of woods, mostly contributed by Arkansas lumber and plywood companies. (Photo on page 316.)

State forestry work began in Arkansas in 1933. It is currently headed by a nine-member commission of which W. Spencer Fox is chairman. Fred H. Lang has been state forester since 1939.

Arkansas has 20 million acres of forest land, or 60 percent of the state's land area. Forest products valued at $300 million are the top ranking industry; 1,631 wood-using plants employ 70,000 workers, and contribute 65 percent of the state's annual labor payroll amounting to $133 million.

The state forestry organization has four main technical branches: fire control, forest management, nursery operations, and information and education.

Navy Establishes Natural Resources Branch

A Natural Resources Management Branch has been established in the U. S. Navy's Bureau of Yards and Docks to handle resources on that Service's lands.

Commander C. R. Zirzow will head the new branch, and it is expected that he will have the assistance of three civilian consultants for forestry, erosion control, and fish and wildlife.

Informed sources say the branch will be the focal point for all technical aspects of natural resources management and conservation on Navy lands. The Navy Department becomes the first of the three defense Services to place its over-all land resources management functions in one office.

Lake S. Gill Retired

Lake S. Gill, chief of the Division of Forest Disease Research at the Rocky Mountain Forest and Range

Lake S. Gill

Experiment Station, Fort Collins, Colo., retired February 29 after nearly 35 years with the U. S. Department of Agriculture.

A graduate of Stanford University, with B.A. and M.A. degrees, he received the Ph.D. from Yale University School of Forestry, majoring in forest pathology.

Dr. Gill entered the Department of Agriculture as a forest pathologist in 1923 where he spent his entire professional career except for military service as an officer in the Army Medical Corps during World War II.

He is the author and co-author of numerous publicatons, and is an authority on mistletoes, pole blight, and other phases of the relationship of forest pathology and silviculture.

Benson H. Paul Retires

Benson H. Paul, veteran forest products technologist, retired from the U. S. Forest Products Laboratory, Madison, Wis., in January.

Mr. Paul was a pioneer in the application of silviculture to the control of wood quality. He initiated research on controlling specific gravity of wood through the regulation of growing space and was for many years chief of the Division of Silvicultural Relations at the laboratory.

Paul's findings have been described in approximately 150 published reports, bulletins, and articles and have substantially increased the available knowledge of timber growth relations.

He gained both his B.S. and Master degrees at Cornell University.

In 1915 he became a forester for the New York Conservation Commission at Albany and for the next 7 years was mainly responsible for administering the state forest tree nurseries.

In 1922 Paul moved to the Forest Products Laboratory. His first assignment was a research problem on "the influence of growth conditions upon the properties of wood" with the objective of explaining the causes of variation in density and strength.

Results of Paul's work have been widely published in forestry and lumber trade journals and a variety of government publications.

Paul has been a member of the SAF for 40 years and was a charter member of the Forest Products Research Society.

Private & Industrial

D. E. Hess New President of APA

The American Pulpwood Association during its annual meeting February 24, elected D. E. Hess as the next president of the Association. Mr. Hess, vice president and general manager of The Glatfelter Pulp Wood Company is the 12th president since the APA was organized in 1934, and succeeds George Amidon of Minnesota.

Mr. Hess has been with this firm, a subsidiary of The P. H. Glatfelter Paper Company, for 14 years. His previous employment includes 12 years' service with the U. S. Government. He is a graduate of Pennsylvania State University, and a resident of Gettysburg, Pa. He also maintains an office in that city.

In addition to the election of Mr. Hess, the following officers were also elected: A. G. Curtis, Bogalusa Div., Crown Zellerbach Corp., and L. J. Kugelman, International Paper Co., vice presidents; and W. S. Bromley, executive secretary and treasurer.

St. Regis Appoints Hardwood Specialist

Appointment of Ivo W. Miller as hardwood management forester of the Southern Woodlands Division of St. Regis Paper Co. has been announced by Albert Ernest, vice president in charge of the division.

In carrying out his assignment of increasing the productivity of hardwoods on St. Regis lands, and consulting with other officials of the company in the optimum marketing and maximum utilization of the hardwoods, Miller will report to Frank Albert, manager of lands and forests for the division.

A 20-year veteran of the U. S. Forest Service, Miller went to St. Regis from Forestry Suppliers at Jackson, Miss., where he had been since 1956. Prior to that, after leaving the Forest Service, he had been a forester, lumber and log buyer for Mississippi Products, Inc., at Jackson.

Miller graduated from the University of Georgia forestry school in 1932 and served with the Seabees in World War II.

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WARD C. WILLIAMS

Williams and Anderson Named AFPI Editors

Ward C. Williams of Mercer Island, Wash., has been appointed editor of publications for American Forest Products Industries, Washington, D. C.

Williams was formerly an associate editor on forest industries trade journals for Miller Freeman Publications in Seattle.

He will be responsible for editing AFPI's monthly *Forestry Digest* and the quarterly *American Tree Farmer* and other publications devoted to the advancement of forestry and tree farming, according to Franklin Bradford, AFPI editorial director.

Williams, a U. S. Navy veteran of World War II, is a 1948 forest management graduate of Oregon State College. He has worked for the U. S. Forest Service in Alaska, Oregon, and Washington. During the period from 1952 through February 1, 1960, he covered forest industries operations in the Pacific Northwest for *The Lumberman, The Timberman,* and *Pulp & Paper* magazines.

AFPI also recently announced the appointment of H. J. Anderson as feature editor in its editorial division. Mr. Anderson has recently returned from a year of study of small woodlot forestry in Norway as a Fulbright scholar. Prior to that he was assistant extension forester in North Carolina.

12th Annual Meeting of Western Dry Kiln Clubs

Technical representatives, lumber seasoning supervisors, and company managers of the western lumber industry will convene in Missoula, Mont., June 23-24 for the 12th annual meeting of the Western Dry Kiln Clubs.

Host for the convention will be the Washington-Idaho-Montana Lumber Seasoning Club.

The Hotel Florence will be the convention headquarters.

Louis A. Rowland, Jr., Joins Forestry Suppliers, Inc.

Louis A. Rowland, Jr., information and education director for the Mississippi Forestry Commission since 1955, has been named sales manager of Forestry Suppliers, Inc. of Jackson, Miss., according to James W. Craig, president.

Mr. Rowland, a 1947 graduate of the School of Forestry, Louisiana State University, started his career with the Louisiana Forestry Commission, first as a fire control assistant and then as a district forester. He moved to Mississippi in 1953 as assistant fire control director, and in 1955 was appointed director of information and education, which includes supervision of the state's forestry public relations program.

W. E. Sanders, NLMA Counsel, Dies

William E. Sanders, 43, assistant general counsel and director of the Tax Division, National Lumber Manufacturers Association, died Sunday, February 14, at Wauchula, Fla.

Mr. Sanders had been in Florida recuperating after prolonged hospitalization resulting from a circulatory ailment.

Sanders was widely recognized as a leading authority on technical problems in federal timber tax matters. He built a reputation both within the industry and with tax officials as a competent spokesman for lumbering interests. He was also Washington spokesman for the industry on problems relating to industrial radio serv-

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ices and served as Washington liaison for the Forest Industries Radio Communications, Inc.

AFPI National Committee Chairmen Named

John H. Hinman, president of American Forest Products Industries, has announced chairmen of AFPI national committees for 1960 as follows:

Program and Planning—Walter J. DeLong of Weyerhaeuser Company, Tacoma, Wash.

Education—Paul M. Dunn, St. Regis Paper Co., New York, N. Y.

Wildlife and Recreation—Casey E. Westell, Jr., Packaging Corporation of America, Filer City, Mich.

Technical Forestry—J. E. McCaffrey, International Paper Co., Mobile, Ala.

Public Relations Consultant—W. Kirk Sutlive, Union Bag-Camp Paper Corporation, Savannah, Ga.

National Council—Dave James, Simpson Timber Co., Seattle, Wash.

Hobart Is Named Virginia's "Man of the Year in Forestry"

At the 17th Annual Meeting of Virginia Forests, Inc., held in Richmond at the Jefferson Hotel in January, Seth Hobart, of Charlottesville, who is chief of the Division of Forest Management of the Virginia Forest Service, was named as Virginia's 1959 "Man of the Year in Forestry." He is the eleventh recipient of this award. The presentation was made by C. R. Chamberlain, of Covington, who is president of the Association. Mr. Hobart attended the University of Michigan and obtained his B.S. degree in forestry in 1916.

The citation read in part, "During his 34 years of service to the people of Virginia, Seth has rarely been in the limelight, but he has brought to his job a steadfastness of purpose, a quiet understanding of human nature, and high ethical and moral standards which have earned for him the loyalty and devotion of his fellow workers in the Division of Forestry. These same attributes, along with his sound professional ability, also have won the respect and admiration of his associates outside the Service who have come to know him and his work."

C. H. Niederhof

Maughan Elected N.C. Association President

William Maughan, consulting forester of Durham, N. C., and former Duke University faculty member, was elected president of the North Carolina Forestry Association at the January meeting of the NCFA board. He succeeds G. E. Jackson.

Other new officers are as follows: T. G. Harris of Halifax Paper Company at Roanoke Rapids, first vice president; Herman Hermelink of Duke Power Company at Charlotte, second vice president; Wayne Corpening of Wachovia Bank at Winston-Salem, third vice president; R. W. Graeber, consulting forester of Raleigh, treasurer; and Ben F. Park of Raleigh, director of public relations and secretary.

C. N. Niederhof Named to S.C. Study Committee

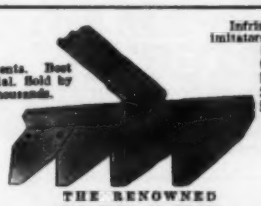
Camman H. Niederhof of Summerville, S. C. has been commissioned by the Governor of South Carolina as a member of the State Forestry Study Committee. Mr. Niederhof is manager of the Wood Procurement Department of West Virginia Pulp and Paper Company's mill at Charleston, S. C.

This eleven-man committee, composed of legislative and civic leaders, is charged with investigating South Carolina's progress and needs in the field of forestry, and with reporting on their findings, with appropriate recommendations, to the governor and to the legislature.

Niederhof is a past president of the Southern Pulpwood Conservation Association and presently serves as a director of the Association. He is a member of the Executive Committee of the Appalachian Section of the SAF, a member of the Foresters Council of South Carolina, the South Carolina Forest Industries Committee, and of the State Chamber of Commerce.

Florida Forestry Association Meets

Highlight of the Florida Forestry Association's 36th annual meeting in Tampa recently was the presentation of a Tree Farmer Certificate to E. V. Whidden by U. S. Senator Spessard Holland. Certification of the property placed Florida's total tree farmer acreage over the 5,000,000 mark.



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At the association's business session officers and directors were elected to serve during the coming year. Officers re-elected included: Charles Soule, Pensacola, president; Norman Herren, Everglades, and W. A. Shands, Gainesville, vice presidents; G. G. Ware, Leesburg, treasurer; and C. G. Geltz, Gainesville, secretary. Justin R. Weddell, Pensacola, continues as the association's executive director.

Schools

University of Michigan Appoints Forest Entomologist to Staff

Appointment of Fred B. Knight (D.F.) as associate professor of forestry in The University of Michigan's School of Natural Resources was approved at the Regents' meeting February 19.

The appointment, effective for a three-year period starting with the University year of 1960-1961, will provide a successor for Professor S. A. Graham who will commence his retirement furlough on July 1, 1960.

Dr. Knight received a Bachelor of Science degree at the University of Maine in 1949 and also holds two degrees (Master and Doctor of Forestry) from Duke University. His doctoral work at Duke was in the field of forest entomology.

Except for the period from 1954 to 1956, while doing doctoral work at Duke, Dr. Knight has been with the U. S. Department of Agriculture as a research forest entomologist. He was at the Southeastern Forest Experiment Station, Asheville, N. C., from 1950 to 1954, and since 1956 has been at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Forestry Award to Ranger

Ralph H. Christopherson, U. S. Forest Service district ranger on the Chippewa National Forest, was recently awarded the University of Minnesota Forestry Club Achievement award. Christopherson is a 1933 graduate of the University School of Forestry, is active in the Society of American Foresters, and is a former Forestry Club member.

The annual award was presented for the first time this year—by Frank Salomonsen, chairman of the club's award committee. The award is designed to honor foresters working in the state who have made major contributions to advancement in forestry.

Forestry Employment

S.A.F. members are privileged to insert one 60-word advertisement in this column without charge. Forest industries desiring to employ foresters may insert advertisements at the rate of $4 per column inch. Copy must be received by the end of this month for an advertisement to appear in the issue after next.

Obviously the Society cannot assume responsibility beyond making it possible for prospective employee and employer to enter into negotiations.

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Positions Wanted

Forester, B.S., Oregon State College, 1957, A.B., General Curriculum, Univ. of California, 1953. Age 29, married. Three years with U. S. Forest Service (sale administration, road inspection and design, cruising, sale layout, slash burning, fire fighting, and limited appraisal and road location work). Desires employment in private industry on Pacific Coast or Rocky Mountain states.
Box K, Journal of Forestry, Mills Building, Washington 6, D. C.

Forester, B.F., 1957, Stephen F. Austin State College. Age 29, single. Experience: 33 months as service forester for state forest service including TSI, prescribed burning, planting, marking, and control and detection of Southern Pine Beetles and Black Headed Sawflies. Prefer management of timber in South. Second choice of location is West.
Box L, Journal of Forestry, Mills Building, Washington 6, D. C.

Forester, B.S., 1949, University of Maine. Age 36, married, three children. Experience: 1½ years N. Y. State Conservation Department; 9 years private industry (New York State) forester and assistant manager, supervision of logging jobs, surveying, land sales, timber sales, scaling; familiar with drawing of logging contracts, leases, deeds. Desire employment in private industry.
Box M, Journal of Forestry, Mills Building, Washington 6, D. C.

Forester, B.S., 1954, Arkansas A. & M., M.F., Louisiana State University. Emphasis placed on forest soils in master's program. Resident course requirements completed for Ph.D. in soils at L.S.U. Age 27, married, one child. Experience with sawmill and pulp and paper company in the South. Desire position with research organization of private industry. Any location will be considered.
Box N, Journal of Forestry, Mills Building, Washington 6, D. C.

Forester, B.S., 1960 Pennsylvania State Univ. Age 21, married, 1 child. Desire to begin career in forestry with private industry. Miscellaneous experience in all phases of forestry. Will consider any location.
Box O, Journal of Forestry, Mills Building, Washington 6, D. C.

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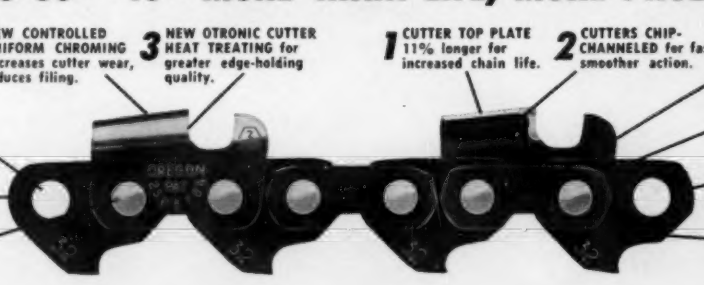

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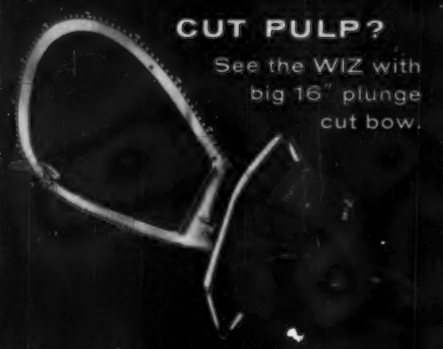

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